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Productivity and Meat Quality with Meat Goat Management

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PRODUCTIVITY AND MEAT QUALITY WITH MEAT GOAT MANAGEMENT

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ABSTRACT

The growth of kid meat goats and their carcass and meat characteristics with monensin sodium or decoquinate coccidiostats in feed were studied. Seventy-three goats of various breeds were divided into six groups with the treatments of control, monensin and decoquinate. Half of the goats were harvested at day 45 and the rest at day 60. The second harvest monensin group had a larger percentage of the goat carcass as the hind leg ($P<0.05$). Additionally, the cooking yields of meat from the first group of harvested goats were greater than the cooking yields from goats in the control and the monensin groups from the second harvest day ($P<0.05$).

Supplementation of permanent pasture with sunn hemp forage or concentrate feed were compared for influences on growth, carcass traits, and meat properties of kid meat goats. Goats that were finished on concentrate had a heavier dressing percentage and heavier cuts ($P<0.05$) than those on sunn hemp. There were no differences in goat meat color nor the percentage of the meat cuts between the feed treatments. Finishing on concentrates may increase meat goat productivity.

Type of packaging alters the color and shelf life of meat during retail display. The *M. Longissimus dorsi* of 24 goat carcasses were randomly assigned to treatments of air-permeable and moisture-impermeable overwrap, vacuum, or nitrite embedded film packaging for 0, 3, 6, 9, and 12 days of retail display. The muscles in nitrite embedded film had greater a* values indicating a brighter red color. Muscles in vacuum packaging with conventional or nitrite embedded film had lower rates of lipid oxidation at Day 12 ($P<0.05$), indicating that the nitrite embedded film has potential for packaging of goat meat for retail self-service meat case sales.

CHAPTER 1. INTRODUCTION

People eat meat to satisfy their nutritional needs and wants. Additionally, humans eat meat for the taste and for customs that have arisen. Meat contributes nutrients like zinc, iron, protein and B complex vitamins that are not commonly found or bioavailable in non-meat sources (Boyle, 1994). Meat is also more affordable when its nutritional value is compared with other food sources (Radke, 2016). One of the oldest domestic animals used for meat is the goat. Consumers of goat meat are from ethnic populations or view it as a lean alternative to other red meats (Paska, 2011). Additionally, consumers view goat meat as a more sustainable alternative to other meats (Weinstein and Scarbrough, 2011).

Goat meat demand in the United States has been increasing with an increase of Hispanic, Asian, and Muslim immigration and their food cultures into the United States (Goat Industry Outlook, 2007). Even though the domestic supply of goats has decreased 18.3% over the past 11 years (NASS, 2007; NASS, 2018), there still is demand for goat meat, which can be seen in the increase in imports of goat meat into the United States (Pinkerton, 2018). A survey of goat producers indicated that the high cost of production hinders domestic goat production along with other challenges (Gillespie et al., 2013).

The perceptions of meat goat producers on the challenges facing the meat goat industry in the U.S. were described by Gillespie et al. (2013). One of the biggest challenges producers face in goat production is lack of internal parasite control (Okpebholo and Kahan, 2007). One of the most economically devastating parasites is the *Eimeria ssp.,* which causes coccidiosis in livestock (Foreyt, 1990). Coccidiosis can negatively affect the growth rate of kid goats and in some cases be fatal. One of the preventative methods recommended is to incorporate coccidiostats in the feed of small ruminants raised in confinement. Two of the most commonly

used coccidiostats, monensin and decoquinate, are effective at preventing coccidiosis, but there is limited knowledge of their comparative effect on meat goat production and goat meat quality.

The largest cost to meat production systems is feed (Qushim et al., 2016). Due to this, farmers are always looking for alternatives to feed their livestock and when to feed concentrates. One alternative with some success is sunn hemp, a summer annual legume that was once thought toxic to livestock, but has since been proven to be quite nutritious for ruminants (NRCS, 1999). Because ethnic consumers prefer goat carcasses with limited amount of fat, producers have limited the amount of time goats have been fed concentrates (Pinkerton and McMillin, 2013). This leads to the question of the optimal time to supplement grazing goats with concentrates, which may influence carcass traits and meat properties.

A meat property used by consumers as an indicator of quality is meat color. The basic purpose of packaging is to protect meat and meat products from microbiological and physio-chemical alterations such as contamination, uptake or loss of moisture, and influences on color, smell and taste (Heinz and Hautzinger, 2007). Comparisons of packaging materials allow processors and retailers to determine appropriate options for packaging goat meat for retail sales. These options would allow goat producers alternative ways to market retail products in self-service meat cases and appeal to both traditional meat goat consumers and customers desiring healthier meat products.

The objectives of the live goat projects were to quantify the effects of different management practices on meat goat production and goat meat quality. The first experiment compared the use of different coccidiostats in supplemental feed. Since monensin sodium has been shown to increase growth rate in other species, the relative growth and subsequent carcass and meat properties with monensin sodium were compared with another coccidiostat

decoquinate. For the next project, the optimal time for a producer to supplement pasture forages with concentrate feed was examined. The two different thoughts are that providing concentrate feed following weaning of kid goats will maintain the faster rate of growth occurring immediately prior to weaning or that feeding concentrates closer to the time of harvesting will allow for more desirable carcass and meat traits. Goat meat is often cut from carcasses in the retail store or shop when a consumer is ready to purchase. The last study compared three packaging options, of air-permeable moisture impermeable, conventional vacuum, or nitrite-embedded packaging that could be used to display fresh goat meat in grocery store self-service meat cases. Changes in color, protein, and lipid oxidation were the focus for this packaging study.

CHAPTER 2. REVIEW OF LITERATURE

2.1. History of Goat Industry

The United States goat industry has undergone many changes including inventory and types of production. Prior to the early 1990's, most of the goats raised in the United States were bred for fiber production (NASS, 1990). However, in 1993, the U.S. Congress passed a bill phasing out the Wool Act of 1954, which planned to cease the incentive payments for wool and mohair in 1966 (Anderson, 2001). Since then, the inventory of Angora goats has decreased, and market experts predict a continual trend is inevitable (Pinkerton and McMillin, 2014). In the same year as Congress' decision, the introduction of the Boer goat breed into the U.S. transformed the goat industry (Machen, 1997).

Many of the slaughter goats in the U.S. prior to the introduction of the Boer breed were culls from dairy and fiber-producing herds. The predominant meat goat at the time was the Spanish goat, which had been primarily used to control brush in low-input production systems (Shelton, 1990). Therefore, the goats in the U.S. had not been heavily selected for meat production, which resulted in poor production traits and variable market weights and carcass traits (Glimp, 1996). The introduction of the Boer and other meat goat breeds in the 1990s brought changes in the meat goat industry (Glimp, 1996).

Increases in ethnic populations in the U.S., especially Latino, Asians, and Muslims, have contributed to an increase in the demand of goat meat. The number of goats slaughtered in USDA-inspected plants and goat meat imported from Australia and New Zealand have sharply increased since 1999. In the 2000s, the U.S. changed from a net exporter to a net importer of goat meat to meet the demand for goat meat (Goat Industry Outlook, 2007). The dramatic change in the landscape of the goat industry from 1990 to 2010 also had profound effects on the research

with goats. Research shifted from primarily fiber emphasis to more milk and meat focus to meet the new demand for goat meat and dairy products (Sahlu, 2009).

2.2. Current Industry

Total goat inventory is down from the 2008 inventory of 3.02 million head (NASS, 2008) to the current 2.62 million head as of January 1, 2018 (NASS, 2019). Angora goat numbers have decreased 34.8 percent from 210,000 (NASS 2008) to 137,000 in 2019 (NASS, 2019). Milk goat numbers have increased 41.0 percent from the 305,000 head (NASS, 2008) to the current 430,000 head (NASS, 2019). Meat goat inventory has decreased 17.8 percent from 2,500,000 (NASS, 2008) to the current 2,055,000 in 2019 (NASS, 2019). An overview of the sheep and goat industry reported that 80% of goats were used for meat production (NASS, 2018). Figure 1 shows the total U.S. inventory of goats by type in the U.S using National Agricultural Statistics Services data from 2007 to 2018.

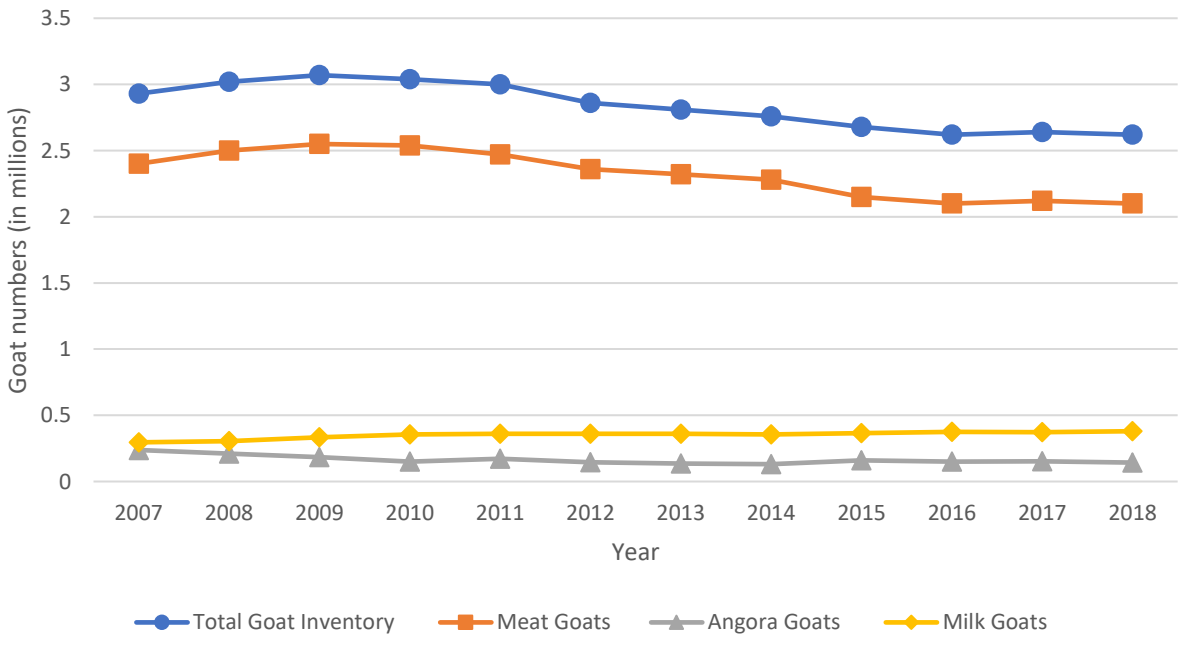

Figure 2. 1. Trends in U.S. total goat inventory, meat goats, Angora goats, and milk goats from 2007 to 2018 (NASS, 2018).

While the majority of goats in the U.S. are meat type breeds, only 42.6 percent of the goat operations in the U.S. are primarily focused on meat production. The rest of the operations are for dairy, fiber, or other production (APHIS, 2012). Figure 2 shows the types of goat operations by region. Operations can range from very small operations to large operations with 17.3% of operations classified as very small operations while 76.8 percent of the operations surveyed were large operations (APHIS, 2012).

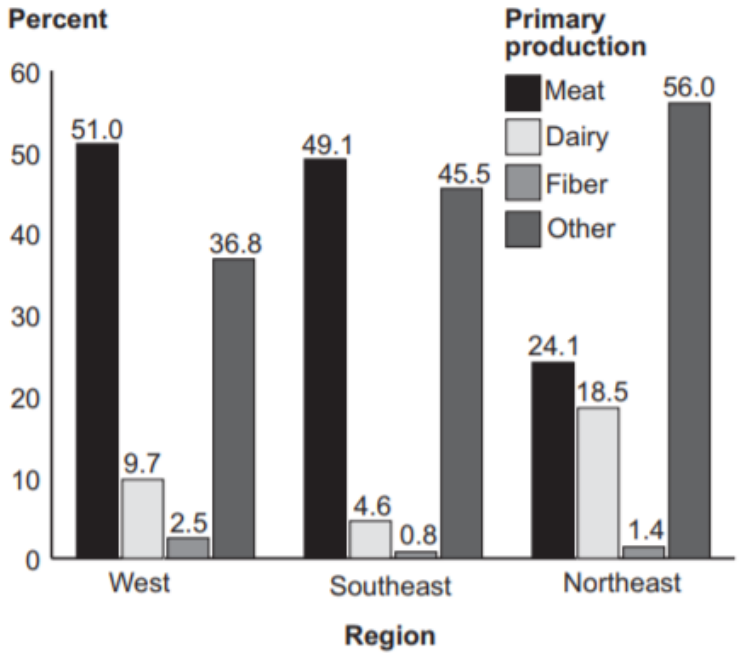

Figure 2. 2. Percentage of operations by primary production and by region (APHIS, 2012).

Even with the majority of operations being focused on meat production, domestic producers are still not meeting the demand of goat meat consumers. Figure 3 shows the number of goats that were slaughtered in the U.S., either federally or other. Additionally, experts estimate that 100,000 head of goats are slaughtered in uninspected conditions and are not recorded in official data (Pinkerton and McMillin, 2014). Figure 4 shows the kilograms of goat meat imported into the U.S. from 2006 through 2016. As the number of goats slaughtered decreased, the amount of goat meat imported into the U.S. increased.

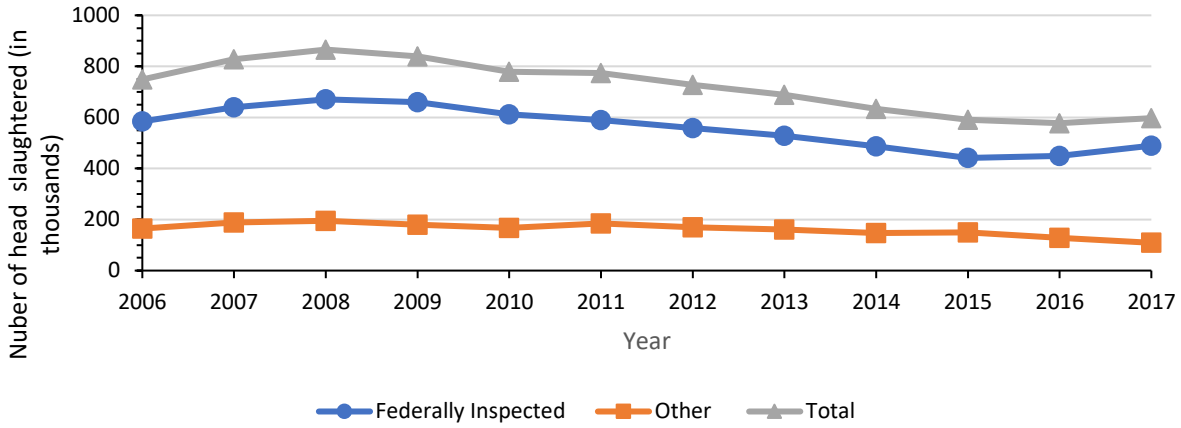

Figure 2. 3. Number of Goats Slaughtered in the U.S. per year 2006 – 2017; Source: USDA, NASS, Livestock Slaughter 2006-2018

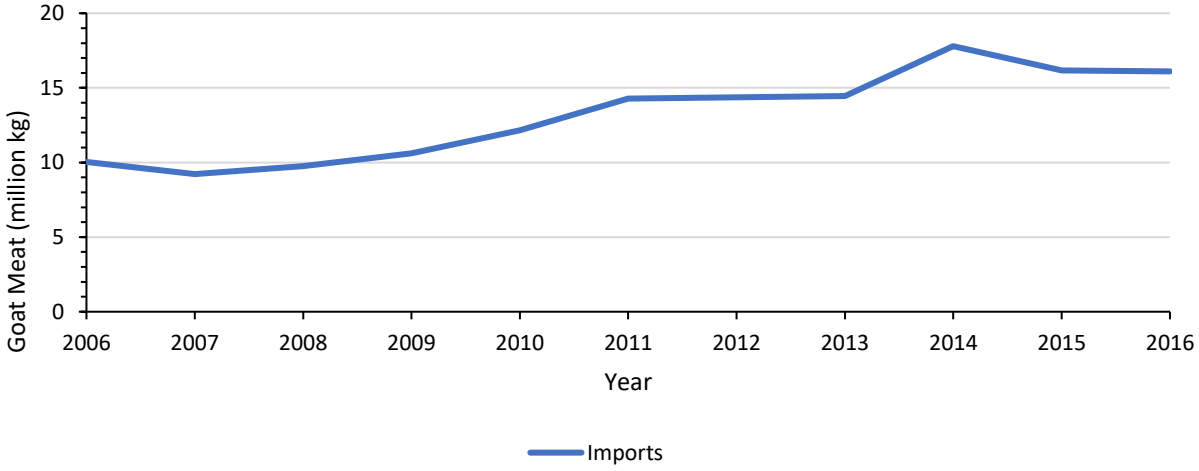

Figure 2. 4. Kilograms of goat meat imported into the U.S. from 2006 – 2016 (Compare Data, FOASTAT, 2018).

The national inventory of meat goats is down 16.0 percent from 2009 (NASS, 2019). The decline in the inventory starting in 2009 was due to the record drought conditions that occurred in the Southwest (Pinkerton and McMillin, 2014). The meat goat industry still has not recovered from this event. However, some industry experts remain optimistic that the national goat inventory will rise again (Pinkerton and McMillin, 2015). The lower national inventory leads to less animals slaughtered and more meat being imported to meet goat meat demand. In order to increase the U.S. meat goat inventory, it has been recommended to increase the number of goat

farms, the size of herds, the size of goats being marketed, the number of kids per doe, or a combination of the solutions (Pinkerton and McMillin, 2014). Regarding those recommendations, the average goat live weight at slaughter has risen 7.1 percent from 28 kilograms in 2006 to 30 kilograms in 2017 (NASS 2006, 2018).

All indications demonstrate that goat producers in the U.S. struggle to produce even half of the goat meat that is consumed in the U.S. annually (Pinkerton, 2014). Reports, also, indicate that consumers prefer fresh domestic goat meat as opposed to frozen imported goat meat (Harrison et al., 2013). The main challenges to the goat industry have been a lack of effective means to control internal parasites, lack of effective marketing strategies for products, inadequate expertise information, and limited access of farmers to financial support (Okpebholo and Kahan, 2007).

2.3. Internal parasite: Coccidia

2.3.1. Overview

Parasites are often divided into two main categories: internal and external. There are multiple types of internal parasites due to their nature of preferring specific hosts and organs. The most common internal parasites in sheep and goats are lung worms, stomach worms, liver flukes, and intestinal parasites, such as coccida and *Haemonchus contortus* (Villarroel, 2013). Parasites grow and reproduce in hot, humid, tropical environments, and the goats that live in those environments are at a high risk of becoming infested (Villarroel, 2013).

Coccidia mostly affect young animals and are not usually a problem unless overcrowding is an issue as is commonly seen in feedlot situations (Villarroel, 2013). In intensive management operations, which are accompanied by high animal density and high productivity, coccidiosis can become an infection of significant economic importance (Foreyt, 1990). The losses can be linked

to reduced production with a moderate infection and without clinical signs (Chartier and Paraud, 2012).

Coccidiosis in goats is caused by the parasite *Eimeria ssp.* *Emmeria ssp.* are host specific and have no cross-infection (McDougald, 1979). There are nine species that infect goats. In the mid-western states of USA, the most frequent species of *Eimeria* encountered in goats are *E. arloingi*, *E. christenseni*, *E. ninakohlyakimovae* and *E. parva* (Lima, 1980).

2.3.2. Life cycle

Eimeria species are homoxenous requiring only one host. The lifecycle includes exogenous and endogenous phases. The exogenous phase of oocyst maturation is a process called sporogony. The endogenous phase includes both asexual and sexual reproduction (Soulsby, 1982). The oocysts passed in the feces are not sporulated. Sporulated oocysts are formed after 2–7 days according to the species of *Eimeria* and the environmental conditions. The sporulated oocysts show a great resistance in the external environment, surviving several months or even more than a year (Chartier and Paraud, 2012).

Once a goat ingests sporulated oocysts, the oocysts undergo a process of excystation. The sporozoites penetrate the epithelial lining of the small intestine. There the sporozoites transform into schizonts. Two asexual replication cycles occur in the small intestine only, or in the small then large intestine, according to the *Eimeria* species. Eventually, the schizozoites penetrate the large intestine epithelial cells. This leads to the production of gamontes, gametes, and then non-sporulated oocysts that are released with the fecal matter (Foreyt, 1990).

2.3.3. Pathogenesis

The prevalence and intensity of excretion of oocysts is highest in animals younger than 4 – 6 months of age (Taylor, 2009). The main symptom is diarrhea. The feces are watery with

clumps of mucus and color changes from brown to yellow or dark tar-like color (Koudela and Bokova, 1998). The general condition of the animal is worsened due to a lack of appetite, and there is also weight loss and dehydration. In certain conditions, a sudden mortality occurs between two and four months of age without any preceding digestive signs (Chartier, 2009). Impaired growth is the main subclinical sign of coccidiosis and is generally revealed during a comparison with other groups (Chartier and Pataud, 2012). Numerous studies have shown the importance of anticoccidial treatments on the growth of animals around the time of weaning and afterwards (Foreyt, 1990).

Coccidiosis is often suspected when there are digestive troubles in young animals bred and raised in poor hygienic conditions and/or intensive management systems. Additionally, sudden mortality around the weaning period would also suggest coccidiosis. In a necropsy examination, the appearance of small grayish-white lesions in the gut of one to two millimeters would indicate coccidiosis (Chartier and Pataud, 2012). The coproscopical examinations should be quantitative and allow, if possible, the diagnosis of the most pathogenic species of *Eimeria* in fecal matter using the McMaster's technique with NaCl or $MgSO_4$ (Yvoré et al., 1987). The presence of characteristic elements including the polar cap, micropyle color, aspect of the oocyst wall, oocystal, and sporocystal residues are needed to distinguish the oocyte (Eckert et al., 1995). There can be large variations in the excretion between animals. Additionally, diarrhea may precede oocyst shedding or oocysts shedding may be high without any clinical signs (Wright and Coop, 2007).

2.3.4. Control

Prevention should include the control of hygienic conditions, reduction of stressors, adequate nutrition, and anticoccidial drugs (Foreyt, 1990). Hygienic measures include clean, dry

buildings, feeders and waterers of appropriate height and design to limit fecal contamination and the crowding of animals. Anticoccidial drugs are coccidiostatic and should be distributed in small doses in feedstuffs over a sufficient period (Chartier and Pataud, 2012).

Treatment should be done as early as possible and with concerns for the whole group of animals since animals showing no obvious signs may contaminate the environment. Treatment can include moving animals to a cleaner environment. Anticoccidial products can be from several chemical families. These products can include sulfonamides, ionophores, and decoquinate. Some alternatives to conventional drugs have been investigated, including condensed tannin-containing plants, such as *Sericea lespedeza* (Chartier and Pataud, 2012).

2.4. Monensin

Monensin is a carboxylic polyether ionophore that is produced by the fermentation of *Streptomyces cinnamonensis* (Sadjadian et al., 2013). Monensin is marketed under the trade name Rumensin® (FIS: Rumensin). It is used for the prevention of coccidiosis caused by *E. crandallis, E. christenseni,* and *E. ninakohlyakimovae.* Directions are to feed as part of the ration at 20 g/ ton continuously to goats as the sole ration when raised in confinement (Elanco, 2017). Ionophores were not impacted by the Veterinary Feed Directive since they are not medically important in human medicine (VFD -Veterinary Feed Directive, 2015).

Ionophores are lipid-soluble molecules that transport ions across lipid cell membranes. Monensin forms complexes with monovalent cations, such as sodium and potassium. As such, it acts as an Na^+/H^+ antiporter. This disruption of cell membrane permeability results in antibacterial effects (Boothe, 2018). Ionophores have an effect on the earlier stages of the *Eimeria* life cycle (Chartier and Paraud, 2012). Monensin blocks the intracellular protein transport, resulting in antibacterial and antimalarial effects (Boothe, 2018). Monensin also

causes a shift in the rumen microflora, which results in a decrease in the acetate producing microbes and an increase in the propionate producing microbes (Bergen and Bates, 1984).

There are several theories that attempt to explain the mode of action of ionophores against coccidia (Chapman, 1984). One hypothesis is that monensin causes vacuolation and swelling of intracellular sporozoites of *E. tenella* (Smith and Strout, 1979). An alternative hypothesis suggests that the disruption of the cation gradients across the host cell membrane by ionophores inhibits the active transport of carbohydrates. In doing so, the ionophores would deprive the developing parasite of nutrients (Wang, 1978, 1982). Additionally, the host cell appears to be unaffected by the concentrations that would be lethal to the sporozoites, indicating that once the parasite is intracellular, the parasite is no longer susceptible to the action of the drug (Smith and Strout, 1980).

Sporozites of *Eimeria* can invade cultured cells when grown in the appropriate media. In doing so, it has been shown that ionophores accumulate in the sporozoites before cell penetration occurs (Itagaki et al., 1974; Smith and Strout, 1979). Once in the cell, monensin causes an increase in Na^+ ion influx and stimulation of (Na^+-K^+)-ATPase that pumps excess Na^+ ions out of the sporozoite (Smith and Galloway, 1983). The accumulation of Na^+ ions causes water to enter by osmosis and the parasite swells and eventually bursts. Differential activity between host cell and parasite might be due to differing chemical compositions of their respective membranes such as a difference in aqueous-hydrocarbon distribution (Smith and Strout, 1979).

Another more recent explanation of the mode of action of monensin is that the drug can interrupt host cell invasion by sporozoites (del Cacho et al., 2007). The outer membrane of the sporozoite contains lipid rafts. A resident protein of lipid rafts, flotillin-1, was identified in sporozoites of *E. tenella* at the apex of the cell, a region that mediates cell invasion. Monensin

was reported to disrupt the localization of flotillin-1 within raft structures, resulting in the loss of ability to invade host cells. This effect was significantly reduced in a monensin-resistant line of *E. tenella* (Chapman et al., 2010).

2.5. Decoquinate

Decoquinate (6-ethyl-(decycloxy) -7-ethoxy-4-hydroxy-3-quinolinecarboxylate) is a quinolone derivative developed initially as an anticoccidial for poultry in 1967 (Williams, 2006). The compound is highly coccidiostatic with activity against sporozoites and trophozoites of the *Eimeria* ssp. and has been shown to prevent coccidiosis in young goats (Foreyt et al., 1986). Decoquinate is marketed as Deccox® (Zoetis, 2011). It is directed to be mixed into a ration at a rate to provide 22.7 mg of decoquinate per 100 lbs of body weight per day for 28 days (Zoetis, 2011). It is still considered an over-the-counter medication by the Veterinary Feed Directive (VFD – Veterinary Feed Directive, 2015). It is prohibited to be fed to goats producing milk for human consumption (Zoetis, 2011).

Decoquinate is a powerful inhibitor of mitochondrial respiration in some protozoal species that acts near the site of cytochrome *b*. The parasite can use other pathways which has led to some decoquinate resistant strands in poultry. Decoquinate has been shown to have effects on multiple stages of the *Eimeria* lifecycle, including static effects on sporozoites, lethal effects on schizonts, and inhibitory effects on oocyst sporulation (Page, 2008).

2.6. Goat Nutrition

Goats are classified as small ruminants. They have a four-compartment stomach consisting of the rumen, reticulum, omasum, and abomasum. The ruminant digestive system is designed to promote bacterial and protozoal fermentation, which allows the utilization of forages that are indigestible by non-ruminant animals (NRC, 2007). As opposed to other ruminants such

as cattle and sheep, which are classified as grazers, goats typically select forages that are classified as browse. This allows for utilization of forages that sheep and cattle do not normally utilize (Dove, 2010). Goats have a tendency to select for forages that are higher from the ground than cattle or sheep (Sanon et al., 2007). Additionally, when provided different forage options, goats had the highest tendency to select for forages greater in dry matter such as cereal grains over *brassica* species and clovers (Bateman et al., 2004). The difference in preference selection of forages allows some farmers to add goats in their existing production (Gillespie et al., 2013). Co-grazing different livestock species allows for farmers to take better advantage of the forage selection habits of each species (Radcliffe et al., 1991). Stocking rates are one of the most important management decisions when co-grazing livestock species, requiring consideration of animal size, stage of performance, forage types, desired length of time desired to maintain the forage, and the productivity of the pasture (Animut and Goestch, 2008). Pastures that are overstocked with lambs and kids can result in lower or even negative weight gains (Norton et al., 1990). Additionally, overstocking animals on increases the concentration of the parasites that can lead to increased cases of diseases (Kumar et al., 2012).

The nutrient requirements for all species depend on the animal's stage of physiological growth and development (NRC, 2007). The goal in all production systems is to optimize animal performance while minimizing input costs (Solaiman, 2010). Knowing the nutritional requirements of the animals can help minimalize costs associated with overfeeding or underfeeding. For example, a mature doe at maintenance will require less nutrients than a doe that is in lactation. Additionally, a wether raised for meat production will have different requirements than a Saanen buck raised for dairy production. Furthermore, the intended growth rate of the animal will influence the nutrient requirements of the animal. For instance, a 25-

kilogram dairy wether fed to gain 100 grams per day would need 111 grams of protein per day while the same 25-kilogram Boer wether fed for maximum growth would need 201 grams of protein per day (NRC, 2007).

2.7. Sunn hemp

Sunn hemp (*Crotaliaria juncea*) is a legume that is grown as a summer annual. It originated in India, where it has been used as a green manure, livestock feed, and a non-wood fiber crop. Due to sunn hemp being a member of the *Crotalaris* genus, some people are wary of using sunn hemp as an agricultural crop, since members of this genus include Johnson grass, which is considered a major weed by most farmers. On the other hand, the genus also includes grain sorghum, which is an important agronomic crop (NRCS, 1999).

All *Crotalaria* are good at producing biomass and fixing nitrogen. They are also resistant to nematodes and grow in low fertility areas. However, some members of the genus are considered noxious weeds, such as Showy Crotalaria. Others in the genus contain toxic alkaloids in their seeds that are poisonous to livestock (NRCS, 1999). This is not a problem with sunn hemp since it has been shown to be non-toxic to poultry and livestock in laboratory tests and feeding trials (Rotar and Joy, 1983).

The crude protein of the whole sunn hemp ranged from 17 percent at 30 days, 11percent at 60 days, and 9 percent at 90 days (Casey et al., 2001). The leaves have had protein levels as high as 30 percent with NDF and ADF levels similar to clover, making it a valuable feedstuff for livestock (Warren et al., 2017).

2.8. Animal Growth Patterns

An animal's growth is a result of the interaction between genetic potential, nutritional plane, hormones, and the environment (Webb et al., 2012). The average daily gain for goats can

range between 0.04 kg/day to 0.36 kg/day (Luginbugl, 2015). The three most common tissues in a livestock growth curve are muscle, bone, and fat. Of these three, the most variation is observed in fat (Mahgoub et al., 2012). Carcass distribution of these tissues is dependent on the animal's maturity, sex, breed, age, and nutrition (Mahgoub et al., 2012). It has been indicated that sex has a larger influence on carcass characteristics than breed when comparing intact males, castrated males, and females of Florida native, Nubian X Florida native, and Spanish X Florida Native breed types (Johnson et al., 1995).

At birth, fat comprises the lowest percentage of body weight of the three main tissues (Webb et al. 2012). Body fat percentages increase with the days on feed (Mahgoub and Lu, 1998; Mahgoub et al., 2004). Sex class also contributes to the amount of fat in goat carcasses. Male goats are reported to have less carcass fat than female goats (Mahgoub and Lu, 1998). Castrating of males has been reported to influence fat accumulation, leading to wethers having a greater fat content than intact buck kids (Ruvauna et al., 1992; Solaiman et al., 2011). When compared to sheep, goats do not deposit as much fat intramuscularly (Santos et al., 2008) or subcutaneously (Mahgoub et al., 2012). Fat deposited subcutaneously over the *Longissimus dorsi* is often not thick enough to accurately measure in market ready kid goats (McMillin et al., 2013). Goat kids tend to deposit the highest proportion of fat as intermuscular fat, then as subcutaneous, omental, kidney, mesenteric, scrotal, udder, and pelvic fat (Maghoub et al., 2004).

Muscle, on the other hand, is the highest proportion by weight at birth (Webb et al., 2012). Similar to fat, variation is seen in muscle among sexes. Buck kids tend to have a greater proportion in the forequarter while does and wethers have a greater proportion in the hindquarter (Mahgoub et al. 2004). Additionally, buck kids have been reported to be more efficient at producing lean compared to wethers (Solaiman et al., 2011). Furthermore, goats compare

favorably to lambs in meat yield due to the fat content of sheep carcasses (Tshbalala et al., 2003; Sen et al., 2004).

The relation of the percentage of bone to the body weight remains mostly constant throughout an animal's life (Webb et al., 2012). When comparing two breeds of goats from Oman, smaller maturing breeds were reported to have a lower percentage of bone compared to the larger maturing breeds at the same weight (Mahgoub and Lu, 1998). After puberty, the length of bone growth begins to slow, but the bone diameter continues to increase until maturity. Castrating buck kids causes bones to increase growth in length with smaller diameters when compared to intact bucks (Webb et al., 2012).

Evaluation of live animals is an important step in selecting a goat at the right time in its growth curve for the desired market. Differences in the expectation of live animals between ethnicities makes it hard to develop an acceptable live goat grading system (Webb et al., 2012). Knowing the method of slaughter is important for consumers when selecting goat carcasses or goat meat (Harrison et al., 2013). The conformation selection criteria put forth by the USDA should be referenced when selecting goats for an optimal muscle to bone ratio (USDA, 2001; McMillin and Pinkerton, 2008).

Dressing percent can be calculated as hot carcass weight/ live weight * 100. It is a measure of the proportion of the live goat that enters the cooler as a carcass (McGregor, 2012). McMillin et al. (2013) reported the average dressing percent of goats to be 48 percent. Other reports have ranged from 44.2-45.1 percent (Gurung et al., 2009) to 53-57 percent (Kadim et al., 2003). The average reported by McMillin et al. (2013) included a variety of breeds at different ages, unlike the other reports. Dressing percent can have a large variation due to many factors including muscling, fat thickness, mud or debris on the hide, gut fill, amount of bone, horns,

abscesses, or bruises (Schweihofer, 2011). Gut fill can vary with the time the animal was fasted. After fasting for 24 hours, the digestive tract is approximately 16 percent of the live weight of the animal (Owen and Norman, 1977). Bucklings have a lower dressing percentage than wethers (Solaiman et al., 2011). Furthermore, intact males were reported to have low dressing percentages at 20 kg live weight when compared to does and wethers. However, these differences disappeared at 26 kg live weight (Allan and Holst, 1989). Dressing percentage has been reported to increase with age (Ruvuana et al., 1992). Intensive feeding has been shown to increase the dressing percentage when compared to non-intensive feeding programs (Johnson and McGowan, 1998). The dressing percentages of goats fed concentrate were reported to be greater than those of range goats (Ryan et al., 2007).

2.9. Meat Properties

2.9.1. pH of Muscle

Following harvest, the body's muscles continues glycogen metabolism, which results in lactic acid production. This continues until the tissues are depleted of glycogen. Once glycogen is low enough to no longer produce adenosine tri-phosphate (ATP) at levels necessary to break the bond between actin and myosin, myosin and actin are no longer held apart, which starts the process of rigor mortis. The accumulation of lactic acid results in a decrease of pH from the live animal of 7.2 to 5.5 in meat (Lawrie, 1992).

Many variables affect the rate at which pH declines during postmortem glycolysis. Species that have greater amounts of fast twitch (white) muscle fibers will have a more rapid decline in pH when compared to species that have more slow twitch (red) muscle fibers (Lawrie, 1992). Additionally, ultimate pH differences have been observed between muscles (Kannan et al., 2001) as a direct result of the ratios of white and red fibers among muscles. The use of

electrical stimulation can be used to accelerate the decline in pH and reduce cold shortening, which occurs when carcasses going through rigor mortis are exposed to temperatures below 0°C. Applying electrical stimulation to goat carcasses resulted in a lower 24-hour pH than in on-stimulated carcasses (Cetin and Topcu, 2009) and hastened onset of rigor mortis due to an acceleration of glycolysis (Cetin et al., 2012). Muscle glycogen concentrations of electrically stimulated carcass sides have been reported to be lower than the controls immediately after application of electrical stimulus (Gadiyaram et al., 2008).

The ultimate pH is primarily affected by the amount of glycogen present in the muscle tissue at the time of harvest. Low levels of glycogen result in a greater ultimate pH and darker muscle tissues in carcasses, commonly referred to as dark cutters because the meat is dark, firm, and dry (DFD). Inducing stress to the animal pre-slaughter can contribute to high ultimate pH in goat carcasses (Webb et al., 2005). Ultimate pH above 6.0 have been reported in goat meat (Kannan et al., 2001; Nuñez Gonzalez et al., 1983; Swan et al., 1998). Goats that are transported immediately prior to slaughter have greater ultimate pH values than goats that are not transported directly before slaughter (Kadim et al., 2006). Castrated male goats have been reported to have a lower ultimate pH than intact males (Abdullah and Musallam, 2007). Additionally, female lambs and goats have been shown to have lower ultimate pH values than intact males (Santos et al., 2008). There have also been reports of differences in ultimate pH between breeds of goats (Swan et al., 1998; Kadim et al., 2003).

2.9.2. Color of Postmortem Muscle

Consumer preference of meat puts emphasis on color as an indicator of meat quality (Kadim and Maghoub, 2012). In order of preference, 2,000 goat meat consumers preferred light pink, medium red, then dark red color (Harrison et al., 2013). Meat color is dependent on the

concentration and form of myoglobin, the status of the iron bound in the compound, and the pH of the muscle (Kadim and Mahgoub, 2012). Depending on the species, maturity, sex, and muscle, the myoglobin concentration varies (Ledward, 1992). Most of the research done on meat color uses an instrument to measure meat color (Tapp et al., 2011) that records three values, L* (0=black; 100=white), a* (-value=green; + value=red), and b* (- value=blue; + value=yellow), based upon the reflectance of light across the spectrum that is reflected back to the sensor in the colorimeter (McGuire, 1992).

Muscle color is highly associated with the maturity of the goat. Older animals are often characterized with having a greater concentration of myoglobin resulting in a darker red color. When comparing 24-30 month-old goats to younger 6-12 month-old goats, Kannan et al. (2003) reported that the older goats had meat with lower L* values and greater a* and chroma values compared to the younger goats. Solaiman et al. (2012) also reported differences in the L*, a*, and b* values of meat between goats of different slaughter ages.

Dark, firm, and dry (DFD) meat has lower numerical values for L*, a*, and b* when compared to normal meat (Bass et al., 2008). Young goats transported prior to slaughter had lower glycogen concentration and lower a* chroma values in meat (Kannan et al., 2003). Transporting goats immediately prior to slaughter lowered the L*, a*, and b* values in the *M. Longissimus dorsi* of goats (Kadim et al., 2006). There were no differences in meat color found in the meat of suckling goat kids of different sexes. However, the goat carcasses were lighter in color than the lamb carcasses of the same chronological age (Santos et al., 2008). Color differences were observed between goat muscles, which could be related to the differences in pH also observed in those muscles (Kannan et al., 2001).

2.9.3. Shear force

Warner-Bratzler shear force (WBSF) has been shown to accurately predict the meat tenderness rating of a consumer (Shackelford et al., 1991). Differences can be due to species, sex, breed, age, and muscles (Lawrie, 1992). WBSF values of greater than 52.68 N were classified to be tough and WBSF values under 42.87 N were tender using beef *Longissimus thoracis* as a model (Destefanis et al., 2008). Reducing the stress on goats prior to slaughter results in more tender goat meat (Kadim et al., 2006). Transporting goats for long distances prior to slaughter can result in less tender meat (Kadim et al., 2014). Meat from intact and castrated males have been shown to be less tender than from females of the same age (Johnson et al., 1995). When comparing goats at 25 kg and 6 kg, the goats of a heavier weight also had greater shear force values in the *Longissimus dorsi* and *Semimembranosus* muscles (Marichal et al., 2003). Some breeds have been shown to contain less collagen in their muscles and therefore have more tender meat, which is shown by Angora goats producing more tender meat than Boer goas (Kadim and Mahgoub, 2012). Additionally, Cashmere goats have been reported to have more tender *Semimembranosus* muscles when compared to Boer and Boer-Cashmere goats, but there was not a difference reported in the *Longissimus dorsi* (Swan et al., 1998). On the other hand, Johnson et al. (1995) found no differences in the meat tenderness between breeds. Instead, it was reported that sex had a greater influence when comparing does, wethers, and bucks of Florida native, Nubian-Florida native, and Spanish-Florida native goats.

When comparing goat meat to sheep meat, reports suggest that lamb meat is more tender than goat meat (Lee et al., 2008; Riley et al., 1989; Schönfeldt et al., 1993; Sen et al., 2004). It has also been observed that sheep patties contain less connective tissue and are more tender than goat patties (Tshabalala et al., 2003). On the other hand, Sen et al. (2004) reported sheep meat as

having greater shear force values than goat meat. However, a sensory panel was unable to distinguish a difference in the tenderness between the two meat types. Furthermore, Santos et al. (2008) observed no differences in the tenderness and fat covering of meat from suckling lambs and goat kids.

Due to the lack of fat covering and their small size, goat carcasses can decrease in temperature rapidly and undergo cold shortening to result in tougher meat (Kannan et al., 2006). Intact males have been observed to decrease in temperature faster than castrated males. This difference in rate of temperature decrease is thought to be affected by the castrated males having a greater fat covering (Abdullah and Musallam, 2007). It has been inferred that the lack of subcutaneous fat on goat carcasses can lead to more drastic cold shortening than might occur in lambs. The increased cold shortening would contribute to the differences in tenderness seen between the species. As a result, the difference in tenderness is thought to be due to differences in the pre-/post- slaughter handling of the species (Warmington and Kirton, 1990).

Following slaughter, goat meat tenderness can be improved though carcass aging, which entails holding a carcass for a specific time in chilled conditions after slaughter. The rate of change in tenderness can depend on the species and type of muscle fibers (Lawrie, 1992). Aging a carcass for 14 days had an effect on the tenderness of goat carcasses; however, this difference was not seen with carcasses held for only three days (King et al., 2004). Kadim et al. (2003) reported that six days of aging was enough to see a difference in tenderness when compared to fewer days of aging. However, Kannan et al. (2006) did not observe differences when comparing carcasses aged for 1, 3, and 6 days post slaughter. The lack of differences was attributed to cold shortening of the carcasses as shortened sarcomeres in the *Longissimus dorsi* led to this hypothesis.

2.10. Packaging

Ethnic consumers prefer to buy goat carcasses or to purchase cuts obtained directly from the carcass while health conscious consumers desire to purchase goat meat in the same types of packaging as other meat. Although air-permeable packaging is most prevalent for raw chilled red meat, vacuum and modified atmosphere packaging offer longer shelf life. McMillin (2017) described the different types of meat packaging and materials used for meat packaging.

A recently developed packaging film (Curwood® FreshCase®, Bemis Corporation, Neenah, WI) is embedded with sodium nitrite crystals (Claus and Du, 2013). This film has been shown to increase the redness of beef steaks when compared to vacuum packaging without sodium nitrite (Yang et al, 2013). Normally, deoxymyoglobin and oxymyoglobin are oxidized to metmyoglobin under partial pressures of oxygen which would occur in polyvinyl chloride film overwrapped packaging environments sometime after the initial blooming time. Metmyoglobin is a major contributor to discoloration of meat (Mancini and Hunt, 2005). The nitrite embedded in the film can, however, cause nitrosylation of the myoglobin to form nitrosomyoglobin, which is bright red in color (Roberts et al., 2017). This new packaging has been shown to improve the color stability in frozen beef (Claus and Du, 2013). Additionally, the nitrite embedded film has been shown to reduce the color discoloration in bison steaks and patties when compared to those in polyvinyl chloride overwrap film packaging (Roberts et al., 2017).

CHAPTER 3. GROWTH AND MEAT PROPERTIES OF KID MEAT GOATS FED DIFFERENT COCCIDIOSTATS

3.1. Introduction

The top reasons that individuals select goat meat enterprises are lifestyle or the fit of goat production with the farming systems (Gillespie et al., 2016). However, producers raising meat goats also face challenges (Gillespie et al., 2013). A survey of producers indicated that the greatest challenge facing the goat industry was internal parasites, with 77% of respondents indicating they strongly or somewhat agreed that this was a challenge (Gillespie et al., 2013). One of the parasites of significant economic impact is coccidia (Foreyt, 1990). There are nine species that commonly infect goat, including *E. arloingi*, *Eimeria christenseni*, *E. ninakohlyakimovae* and *E. parva* (Lima, 1980). Coccidia affect young animals and are generally not a problem unless overcrowding is an issue, which may occur in feedlot situations (Villarreol, 2013). There are a variety of ways to control coccidia, including maintaining hygienic conditions, reduction of stressors, adequate nutrition, and anticoccidial drugs (Foreyt, 1990). Two common anticoccidial agents for ruminant livestock are Deccox® and Rumensin®. The active drug in Deccox® is decoquinate (Zoetis, 2011), while the active drug in Rumensin® is monensin sodium (Elanco, 2017). Each of these pharmaceuticals has different modes of actions. While both have been proven to be efficient at controlling coccidia, there have been minimal data on the effects of each coccidiostat on goat meat and carcass qualities and on meat goat performance.

3.2. Materials and Methods

3.2.1. Animal Use

The Louisiana State University Agricultural Center Institutional Animal Care and Use Committee approved the research protocol (A2018-08) for care and use of live animals. Animals were housed at the Central Research Station in Baton Rouge, Louisiana.

3.2.2. Animal Procurement

Savannah-Spanish wethers (n=26) were purchased from rancher Shawn Ladreau in Kiln, Mississippi and transported approximately 188 kilometers to Baton Rouge, Louisiana. Additional Boer-Spanish wethers (n=30) were purchased through Wald Livestock in Kenner, Louisiana and transported 143 kilometers to Baton Rouge, Louisiana. Upon arrival at Central Research Station, the goats were inspected by a Louisiana State University (LSU) veterinarian and held in quarantine for a minimum of 14 days. During the quarantine period, the animals were ear tagged, dewormed with Prohibit® (levamisole hydrochloride, AgriLabs, St. Joseph, MO), deliced with Ultra Boss® (permethrin 5% and piperonyl butoxide 5%, Merck, Kenilworth, NJ), and vaccinated with 2 cc of *Clostridium perfringens* types C&D-tetanus toxoid (CD/T, Boehringer Ingelheim Animal Health USA Inc., Duluth, GA) subcutaneously under the supervision of a LSU veterinarian. All goats received a second injection of CD/T 21 days later. Goats had access to *ad libitum* water and pelleted feed (Producers Show Goat NM, Producers Cooperative Association, Bryan, TX). Following quarantine, the animals were moved to the Small Ruminant Unit. Additional crossbred Savannah-Myotonic wethers (n=17) from Central Research Station were combined with the other goats with access to permanent pastures and water, and separated into their treatment diet groups.

3.2.3. Nutrition

The nutrient analysis of the Producers Show Goat feed is in Table 3.1. All three diets used this base formulation with the following modifications: Diet 1 (control): no changes were made; Diet 2 (decoquinate): decoquinate added at a rate of 0.025g/kg; Diet 3 (monensin): monensin added at a rate of 0.022 g/kg. Pelleted rations needed for the duration of the trial were delivered to Central Research Station immediately prior to the study in bags weighing approximately 22.68 kg stacked on pallets.

Table 3. 1. Guaranteed analysis of Producers Show Goat from Producers Cooperative Association, Bryan, Texas

Nutrient composition	
Crude Protein (Min)……	16.00 %
Crude Fat (Min)..……	3.50 %
Crude Fiber (Max)……..…	14.00 %
Calcium (Min)…….….	0.80%
Calcium (Max)…….	1.20 %
Phosphorus (Min)……	0.35 %
Salt (Min)……..……	0.80 %
Salt (Max)……	1.20 %
Copper (Min)……..……	29 ppm
Copper (Max)……..	33 ppm
Selenium (Min)……..……..	0.20 ppm
Vitamin A (Min)……	12,600 IU/lb

Random samples of each diet were taken from multiple bags and mixed thoroughly for nutrient assessment. Additionally, multiple samples of pasture forage were taken for nutrient analysis from each paddock housing goats. Samples were taken using a 33 cm by 54 cm rectangle form randomly thrown throughout the pasture. All of the forage was collected from within the rectangle. The samples were dried in forced air ovens at 100°C to measure moisture content before analysis for other nutrients. The average moisture content of the pasture forage samples was 42.26 %. Samples of forages and the three feed formulations were analyzed by the Louisiana State University Agricultural Chemistry laboratory for protein, crude fat, crude fiber, acid detergent fiber (ADF), and minerals including: boron, calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, sulphur, zinc, aluminum, barium, cadmium, chromium, cobalt, lead, molybdenum, nickel, selenium, and arsenic (Table 3.2).

Table 3. 2. Analysis of feed and pasture

Nutrient component	Pasture[1]	Control[2]	Monensin[2]	Decoquinate[2]
Protein, %	8.73	16.50	16.45	15.00
Crude Fat, %	0.58	3.45	3.65	3.50
Crude Fiber, %	29.98	14.09	13.74	13.25
Moisture, %	9.01	11.53	11.22	11.90
Acid Detergent Fiber, %	45.80	17.31	17.54	16.72
Boron, ppm	31.50	<16.00	16.90	<16.00
Calcium, %	0.48	0.99	0.86	0.86
Copper, ppm	10.03	42.05	22.90	23.45
Iron, ppm	200.33	242.50	188.00	229.50

(table cont'd)

Nutrient component	Pasture[1]	Control[2]	Monensin[2]	Decoquinate[2]
Magnesium, %	0.21	0.22	0.21	0.21
Manganese, ppm	134.65	79.85	99.40	70.90
Phosphorus, %	0.18	0.35	0.38	0.35
Potassium, %	0.99	1.09	1.11	1.08
Sodium, %	0.13	0.42	0.36	0.39
Sulphur, %	0.18	0.18	0.19	0.19
Zinc, ppm	87.12	94.70	107.50	96.95
Aluminum, ppm	161.00	163.50	113.00	149.50
Barium, ppm	15.63	14.10	10.35	10.75
Cadmium, ppm	<0.4	<0.4	<0.4	<0.4
Chromium, ppm	1.23	1.41	0.82	1.44
Cobalt, ppm	<0.4	1.98	1.18	1.12
Lead, ppm	<1.2	<1.2	<1.2	<1.2
Molybdenum, ppm	1.26	5.24	2.45	2.62
Nickel, ppm	1.41	2.47	1.52	1.98
Selenium, ppm	<14.0	<14.0	<14.0	<14.0
Arsenic, ppm	<4.0	<4.0	<4.0	<4.0

[1] on dry matter basis
[2] on as fed basis

3.2.4. Animal Allotment

Savannah-Spanish (n=26), Boer-Spanish (n=30), and Savannah-Myotonic wethers (n=17) were stratified by weight and breed to allocate the heaviest goats in descending weight order from each breed randomly to six paddocks (three diets each in two paddocks) consisting of shed

space and pasture access. Each paddock (5 paddocks of 12 goats and one paddock of 13 goats) was randomly assigned so that each of the two sheds had one of each dietary treatment of no coccidiostat (control), monensin, or decoquinate.

The paddocks consisted of approximately 41 m^2 covered portion in the shed with dirt floors and approximately 946 m^2 pasture fenced by electric netting (SS Permanent 10/48/6, Premier 1 Supplies LLC, Washington, Iowa). Water was provided in large tubs in each shed.

3.2.5. Live Animal Care

Goats in each paddock were given feed twice daily, once in the morning around dawn and once in the evening around dusk. The goats in each paddock were fed at 3 percent of the total goat body weight in the paddock daily. Wooden trough feeders along the length of each shed had one continuous opening for the goats. Twice a week, prior to feeding, the feed remaining in the troughs was retrieved from each trough and weighed as refusal. Once a week, each animal was reweighed, and feed was adjusted to 3 percent of the revised total weights of the goats in the paddock. Prior to the next feeding of the animals, while the feed troughs were still clean, the animals were rotated to another paddock to eliminate any shed or paddock effect. The equation used for feed allowance was (total paddock goat live weight * 0.03)/2 = amount fed at each feeding. Throughout the project, the animals were FAMACHA scored and checked for lice. Animals were treated if they had a FAMACHA score of 3 or greater with dewormer Prohibit® and Ultra Boss® (perethrin 5% and piperonyl butoxide 5%, Merck, Kenilworth, NJ) was applied for the control of biting and sucking lice as needed.

During quarantine, one of the animals exhibited an abscess on the front left coronary band. The front medial claw was removed by LSU veterinarians, and the goat was placed on the trial after recovery.

3.2.6. Live Animal Measurements

On October 13th, goats were weighed for the trial starting weights. Linear measurements were recorded for the chine length, loin length, rump length, withers height, hip height, heart girth, barrel circumference, chest width, and chest depth using guidelines by McMillin et al. (2013). Live conformation scores were assigned by a trained researcher (McMillin and Pinkerton, 2008). Weights and linear measurements were taken on days 0, 28, 42, and 56. The goats were placed on stands with head holds to keep the animals still while the measurements were taken. Average daily gains were calculated as weight on the specific day minus the previous weight divided by days between weights. Day 0 measurements were excluded from the data analysis due to errors in measurements made by inexperienced researchers.

3.2.7. Rumen Fluid Collection and Sample preparation

Rumen fluid for volatile fatty acid analysis from four animals (n= 24) from each paddock was collected via stomach tube prior to the afternoon feedings on day 0 and 34. Immediately after collection, rumen fluid pH was measured. After pH was recorded, 1 mL of phosphoric acid (20% w/v) was added. All rumen fluid was stored at -20°C and protected from UV light until analysis.

A 4 mL sample of acidified ruminal fluid was combined with an internal standard for volatile fatty acid quantification. The internal standard consisted of 1 mL of 25% (wt/wt) meta-phosphoric acid containing 10 g/L 2-ethylbutyric acid. The combined ruminal fluid and meta-phosphoric acid mixture was centrifuged at 30,000 x g for 20 min. A Shimadzu GC2010 equipped with a 15-m EC-1000 column with an internal diameter of 0.53 mm and a film thickness of 1.2 μm (Alltech Associates, Inc.; Deerfield, IL) was used to measure the concentrations of each VFA. Both reagent preparation procedure and temperature gradient for

volatile fatty acid analysis were adapted from Grisby et al. (1992) and Bateman et al. (2002) following the procedure of Doescher (2010) (Appendix A).

3.2.8. Fecal Collection and Fecal Counts

Rectal fecal samples were collected every two weeks from individual animals for fecal egg counts. Additionally, FAMACHA scores were taken every two weeks with the collection of fecal samples. The goats were placed on stands to keep them in place during these procedures. Fecal samples were refrigerated until the fecal egg count (FEC) was determined with a modified McMaster procedure (Whitlock, 1948). Two grams of feces were weighed and dispersed in a cup using a tongue depressor. Thirty ml of saturated salt solution (737g of iodized salt dissolved in 3000 ml of tap water) was added to the feces and mixed by hand. This was followed by mixing with an electric paddle type mixer (DrinkMaster® Drink Mixer, Hamilton Beach Brands, Inc., Glen Allen, NC) to break up the feces. Before the solution could settle, a 1 ml sample of the solution was pipetted and placed into one half of a McMaster slide chamber (Chalex Corporation, Issaquah, WA). This process was then repeated for the other half of the McMaster slide. From both sides of the chamber, the number of coccidia oocytes were counted under each grid with each egg representing 50 eggs per gram. The total number of oocytes counted was then multiplied by 50 to get an estimate of the number of eggs per gram of feces.

3.2.9. Harvesting procedure

Half of the animals from each breed in each pen with the heaviest live weights were selected for harvest at day 45 and the remainder of the goats were slaughtered at day 60. Selected animals for harvest were removed and grouped into holding pens without feed twenty-four hours prior to slaughter. Water continued to be available *ad libitum*. The animals were transported roughly 6.5 kilometers from the Central Research Station to the LSU Meat Laboratory on the

morning of harvest. All goats were reweighed immediately upon exiting the trailer. Goats were rendered unconscious via captive bolt (model Cash Special captive bolt stunner 4100R) under the observation of Louisiana Department of Agriculture and Forestry state meat inspectors and exsanguinated. Hides were removed by pulling with an electric cable hoist (Model Number W154236, Yale Eaton, Forest City, Arkansas). After evisceration, carcasses were washed with water warmer than 35° C, weighed, and chilled overnight at 3° C prior to carcass evaluation.

3.2.10. Carcass Measurements

Temperature and pH were measured at the time of hide removal and at 1 hour, 3 hours and 24 hours after stunning using a pH meter (Hach model H160, Loveland, CO, USA) with attached ISFET pH stainless steel microbe piercing probe with waterproof connector (Hach model PHW57-SS, Loveland, CO, USA) inserted into the center of the *M. Semimembranosus* as described by Kerth et al. (1999). Ten carcasses had digital temperature data loggers (TermoWorks model ThermaData Series II Temp Logger TC) in the *M. Semimembranosus* to continuously monitor the carcass temperature decline during chilling.

After 24 hours of chilling, the circumferences of the rear legs at the widest dimension (center of the legs), of the rear legs at the tail, of the body at the heart girth (3rd and 4th ribs), and of the body at the chest (1st rib) and the length from the first rib to the aitch bone were measured using a tape measure. Carcass conformation, percent kidney, pelvic and heart fat (KPH), flank color, and external fat covering were evaluated by experienced personnel (McMillan and Pinkerton, 2008). Goats were ribbed between the 12th and 13th ribs using a handsaw. Right and left *M. Longissimus dorsi thoracis* rib eye areas were traced on an acetate pad (aquabee acetate pad, Bee Paper Company, United States). The rib eye area on each carcass

was measured to the nearest square centimeter three times with a digital planimeter (Topcon Model KP-82N, Japan) to calculate an average for the rib eye area.

A Minolta spectrophotometer (model CM 508d, Konica Minolta, USA) with aperture opening 10.32 mm, illumination type D65, optical geometry 45°, and observer angle 2° was used to measure the surface L*, a* and b* color values of the *M. Rectus abdominis* in the carcass flank. The spectrophotometer averaged three readings for each of three locations that were then averaged for the final color reading.

Carcasses were weighed after chilling and carcass shrinkage calculated as (hot carcass - chilled carcass weight) / hot carcass weight * 100. Twenty-four hours post mortem, the KPH fat was removed prior to the carcasses being split into left and right sides through the backbone using a band saw (Butcher Boy SA20-F, Lasar MFG. Company, Inc. Los Angeles, CA). The right side of each carcass was fabricated into primal cuts using the food service style (USDA, 2001), with an additional transverse cut between the 4^{th} and 5^{th} ribs as seen in Figure 3.1. To obtain individual weights for this shank cut that is usually sold bone-in, carcasses were cut at the joint connecting the humerus bone to the radius and ulna, which was a deviation from the Fresh Goat IMPS food service style (USDA, 2001). Primal cuts were further separated into sub-primal cuts and retail cuts. Sub-primal cuts (foreleg without shank and trotters, shoulder without neck, back and loin, and the hind legs without shank and trotters) were trimmed of fat before manual deboning with a knife to obtain boneless commercial lean yields. Weights were recorded for KPH, foreleg with shank and trotter, foreleg and shank with trotter removed, foreleg with shank and trotter removed, fore trotter, fore shank, boneless foreleg, shoulder with neck, shoulder without neck, neck, boneless shoulder, ribs with breast plate, ribs with breast plate removed, hind leg with shank and trotter, hind leg and shank with trotter removed, hind leg with shank and

trotter removed, hind shank, hind trotter, boneless hind leg, back and loin with adhering fat and lean, and *M. Semimembranosus.* Cutting instructions similar to these have been reported on goats of different sizes (McMillin et al., 2013).

Figure 3. 1. Fabricated carcass side into cuts used in the study

The *M. Semimembranosus* muscles were packaged in vacuum pouches (40.64 cm by 50.80 3-mil standard barrier nylon-polyethylene, Ultra Source; Kansas City, MO) with a slight vacuum (Turbovac, Howden Food Equipment B.V., The Netherlands). Packages were stored for a week at 3°C before samples were removed from the packaging and weighed. Two 2.54 cm steaks were cut from the *M. Semimembranosus*, weighed, and then placed onto wire mesh in individual disposable aluminum pans (22 cm x 15 cm x 3 cm) to allow for drainage of drip during cooking. Samples were cooked in a conveyer oven (Lincoln model 1130-000-U-k1837, Fort Wayne, IN, USA) at a temperature of 204.4°C for 13 min to achieve an internal temperature of 75°C. The samples were cooled and reweighed to calculate cooking yield before storing at 4°C overnight in clean baking pans (43.18 cm x 63.5 cm x 2.54 cm) covered with aluminum foil.

Cylindrical cores (n=3) of 12.5 mm diameter (Schönfeldt et al., 1993) were removed parallel with muscle fibers from cooked cooled samples. Cores were sheared perpendicular to the longitudinal orientation of the muscle fibers with a Warner-Bratzler shear attachment (Schönfeldt et al., 1993) using a 25 kg load cell and 240 mm per minute crosshead speed (Texture Technologies Corp. model TA HD Plus, Scarsdale, New York). Peak force was measured in grams.

3.2.11. Data Analysis

The R-studio (Version 3.5.2, Rstudio, Boston, MA) aov function was used to analyze the data. Fixed effects included the treatment, harvest day, breed, and interactions between them. Means were determined as least square means and differences were determined at $P<0.05$ utilizing the post hoc Tukey test. Pearson correlations were also calculated using the rcorr function. The correlations are in Appendix D.

3.3. Results and Discussion

3.3.1. Weights and Average Daily Gain

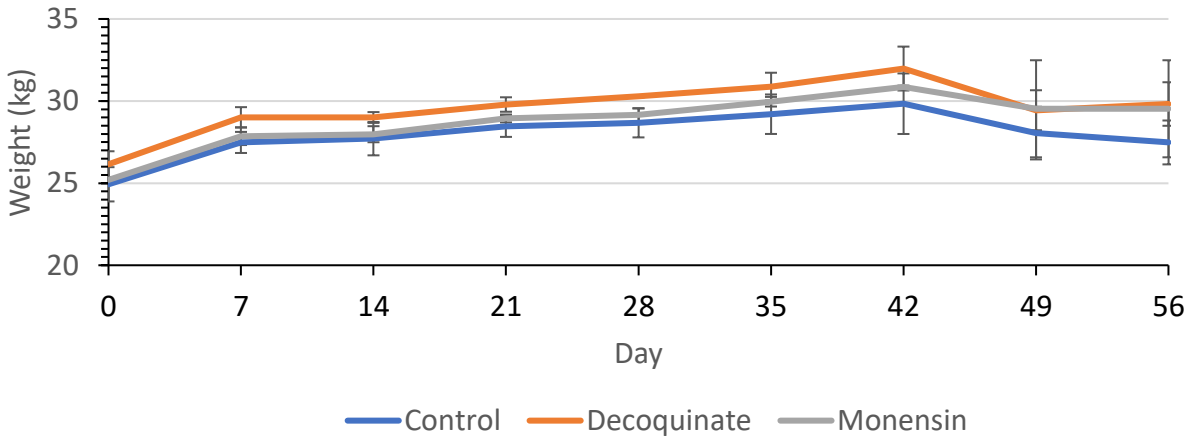

Figure 3. 2. Average weight in kilograms by breed

The least square means and mean square errors for the weekly weights (kilograms) and average daily gain (kilograms per day) by treatment are in Table 3.3 and Table 3.4. Figure 3.1 shows the least square means and standard deviations of the weekly weights of the goats by treatment. There were no significant differences in any of the weekly weights or average daily gains among the treatments. The differences in initial weights of goats from the different combinations of breeds used in the experiment added to the variation of the weights. The average daily gains were in the range of the 0.04 kg/day to 0.36 kg/day reported for goats by Luginbugl (2015). The apparent decrease in weight after the first harvest (day 42) is due to the selection of the heaviest goats of each breed for harvest. The remaining goats were expected to increase growth with decreased competition and an additional two weeks on feed. The smaller goats also led to the lower average daily gains from harvest 1. There was some weight lost in the last 14 days of the experiment, which could be due to harvest of the heaviest wethers from each pen. This left the rest of the wethers to reestablish a social hierarchy and utilized more of their energy. This was noted in observing the remaining goats being more aggressive towards each other following the first harvest.

Table 3. 3. Least square means and mean squared error for the weekly meat goat weights (kilograms) by treatments

Treatment	Day								
	0	7	14	21	28	35	42	49	56
Control	24.93	27.48	27.71	28.46	28.67	29.20	29.84	28.05	27.48
Decoquinate[a]	26.15	29.01	29.00	29.79	30.29	30.88	31.98	29.44	29.82
Monensin[b]	25.20	27.86	27.98	28.94	29.16	29.96	30.86	29.53	29.53
MSE	0.5775	0.3613	0.4596	0.2209	0.9461	0.7493	1.732	4.264	4.093

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

Table 3. 4. Least square means and mean square error for average daily gain (kilograms per day) by treatment

Treatment	ADG Day 56[c]	ADG Day 42	ADG Day 42	AVG Day 42	AVG Day 42 through 56	AVG Day 56
Harvest group		1 and 2[d]	1[e]	2[f]	2[g]	2[h]
Control	0.05	0.12	0.12	0.12	-0.02	0.08
Decoquinate[a]	0.06	0.14	0.15	0.13	-0.03	0.09
Monensin[b]	0.08	0.13	0.14	0.13	0.003	0.10
MSE	0.0008	0.0002	0.0003		0.002	1.68

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg
[c] Average Daily Gain = (Average initial weight – average day 56 weight)/56
[d] Average Daily Gain = (Average initial weight – average day 42 weight)/42
[e] Average Daily Gain = (Average harvest 1 initial weight – average harvest 1 day 42 weight)/42
[f] Average Daily Gain = (Average harvest 2 initial weight – average harvest 2 day 42 weight)/42
[g] Average Daily Gain = (Average harvest 2 day 42 weight – average harvest 2 day 56 weight)/14
[h] Average Daily Gain = (Average harvest 2 initial weight – average harvest 2 day 56 weight)/56

The least square means and mean square errors for the weekly weights (kilograms) and average daily gain (kilograms per day) by breed are in Table 3.5 and Table 3.6. Savannah-Spanish cross goats were lighter than the goats in the other two crossbred types for the first 42 days of the experiment. Additionally, the average daily gain for the Savannah-Spanish goat group was the highest when averaged for both harvests at day 42. The decrease in the average weights of the goats following day 42 can be attributed to the selection of the heavier goats for the first harvest day. The increased average daily gain of the Savannah-Spanish and Savannah-Myotonic breeds can be attributed to them being younger than the Boer-Spanish goats that were used on the project. The older animals would be closer to reaching their mature weights when the average daily gains are less than in younger animals.

Table 3. 5. Least square means and mean squared error for the weekly meat goat weights (kilograms) by breed

Breed	Day								
	0	7	14	21	28	35	42	49	56
Boer-Spanish	28.00[a]	30.59[a]	30.62[a]	31.33[a]	31.27[a]	31.33[a]	32.14[ab]	31.86[a]	32.24[a]
Savannah – Spanish	21.53[b]	24.79[b]	24.86[b]	25.78[b]	26.29[b]	27.36[b]	28.21[b]	26.19[b]	25.93[b]
Savannah -Myotonic	26.98[a]	28.98[a]	29.27[a]	30.20[a]	30.90[a]	31.91[a]	32.98[a]	29.07[ab]	28.73[ab]
MSE	23.19	27.11	27.79	29.41	31.53	35.95	39.96	28.89	27.44

[ab] Least square means for a trait with different letters are different (P<0.05)

Table 3. 6. Least square means and mean square error for average daily gain (kilograms per day) by breed

Breed	ADG Day 42	ADG Day 42	AVG Day 42	AVG Day 42 through 56	AVG Day 56
Harvest group	1 and 2[d]	1[e]	2[f]	2[g]	2[h]
Boer-Spanish	0.10[b]	0.09[c]	0.10[bc]	-0.04	0.07[b]
Savannah-Spanish	0.16[a]	0.16[ab]	0.16[ab]	-0.01	0.12[a]
Savannah-Myotonic	0.14[a]	0.22[a]	0.11[bc]	0.01	0.09[ab]
MSE	0.004	0.003		0.007	0.002

[abc] Least square means for a trait with different letters are different (P<0.05)
[d] Average Daily Gain = (Average initial weight – average day 42 weight)/42
[e] Average Daily Gain = (Average harvest 1 initial weight – average harvest 1 day 42 weight)/42
[f] Average Daily Gain = (Average harvest 2 initial weight – average harvest 2 day 42 weight)/42
[g] Average Daily Gain = (Average harvest 2 day 42 weight – average harvest 2 day 56 weight)/14
[h] Average Daily Gain = (Average harvest 2 initial weight – average harvest 2 day 56 weight)/56

The weekly weights (kilograms) and average daily gains (kilograms per day) of the goats by breed and treatment are in Table 3.7 and Table 3.8. The Savanna-Myotonic wethers in the decoquinate treatment were heavier than the Savannah-Spanish wethers in the control group at

day 42. Following day 42, the loss of weight is due do the selection of the heavier goats for the first harvest. The day 42 average daily gains for the decoquinate Savannah-Myotonic goats had greater average daily gains then all the groups of Boer-Spanish treatments. The lower average daily gains with the Boer-Spanish goats could be indicative of their age as older goats have lower weight gains as they approach their mature weight.

Table 3. 7. Least square means and mean squared error for the weekly meat goat weights (kilograms) by treatment and breed

Treatment: Breed	Day 0	7	14	21	28	35	42	49	56
Control: Boer-Spanish	27.94	30.62	30.84	31.57	31.62	31.84	32.43[ab]	32.00	32.09
Control: Savannah-Spanish	20.52	23.93	24.10	24.89	25.06	25.91	26.25[b]	25.40	24.49
Control: Savannah-Myotonic	25.78	26.99	27.29	28.05	28.58	29.18	30.32[ab]	26.76	25.85
Decoquinate[c]: Boer-Spanish	28.03	30.71	30.66	31.34	31.16	30.80	31.52[ab]	31.41	31.75
Decoquinate[c]: Savannah-Spanish	22.38	25.55	25.10	26.16	26.91	28.07	29.28[ab]	25.51	25.97
Decoquinate[c]: Savannah-Myotonic	29.48	32.21	33.02	33.57	35.02	36.47	38.28[a]	31.75	32.05
Monensin[d]: Boer-Spanish	28.03	30.44	30.35	31.07	31.03	31.34	32.48[ab]	32.21	32.89
Monensin[d]: Savannah-Spanish	21.57	24.80	25.30	26.21	26.76	27.92	28.88[ab]	27.67	27.33
Monensin[d]: Savannah-Myotonic	26.08	28.27	28.12	29.56	29.79	30.84	31.22[ab]	29.30	29.03
MSE	24.43	28.24	28.67	30.64	32.23	36.43	39.76	33.18	30.37

[ab] Least square means for a trait with different letters are different ($P<0.05$)
[c] Decoquinate concentration 0.025 g/kg

[d] Monensin concentration 0.022 g/kg

Table 3. 8. Least square means and mean square error for average daily gain (kilograms per day) by treatment and breed

Treatment: Breed	ADG Day 42 Harvest 1 and 2[f]	ADG Day 42 Harvest 1[g]	AVG Day 42 Harvest 2[h]	AVG Day 42 through 56 Harvest 2[i]	AVG Day 56 Harvest 2[j]
Control: Boer-Spanish	0.11[bc]	0.10[b]	0.11[b]	-0.06	0.07
Control: Savannah-Spanish	0.14[abc]	0.11[b]	0.16[ab]	-0.02	0.12
Control: Savannah-Myotonic	0.11[abc]	0.17[ab]	0.08[b]	0.02	0.06
Decoquinate[d]: Boer-Spanish	0.08[c]	0.07[b]	0.10[b]	-0.07	0.06
Decoquinate[d]: Savannah-Spanish	0.16[abc]	0.19[ab]	0.13[ab]	-0.01	0.09
Decoquinae[d]: Savannah-Myotonic	0.21[a]	0.28[a]	0.17[a]	0.02	0.13
Monensin[e]: Boer-Spanish	0.11[bc]	0.11[b]	0.10[b]	0.02	0.08
Monensin[e]: Savannah-Spanish	0.17[ab]	0.17[ab]	0.18[a]	0.01	0.14
Monensin[e]: Savannah-Myotonic	0.12[abc]	0.22[ab]	0.10[b]	-0.01	0.8
MSE	0.003	0.003	0.003	0.007	0.001

[abc] Least square means for a trait with different letters are different ($P<0.05$)
[d] Decoquinate concentration 0.025 g/kg
[e] Monensin concentration 0.022 g/kg
[f] Average Daily Gain = (Average initial weight – average day 42 weight)/42
[g] Average Daily Gain = (Average harvest 1 initial weight – average harvest 1 day 42 weight)/42
[h] Average Daily Gain = (Average harvest 2 initial weight – average harvest 2 day 42 weight)/42
[i] Average Daily Gain = (Average harvest 2 day 42 weight – average harvest 2 day 56 weight)/14
[j] Average Daily Gain = (Average harvest 2 initial weight – average harvest 2 day 56 weight)/56

3.3.2. Linear Measurements

Least Square means and mean squared error for linear measurements by treatment are in Table 3.9. The measurements were analyzed so that each treatment day combination was compared to the other treatment day combinations. The majority of the measurements did not change throughout the experiment. The decrease from day 42 to day 56 is due to the selection of the heavier and therefore larger goats for harvest 1 because the remaining goats were lighter and smaller than those selected for the first harvest. There were differences in hip heights and withers height ($P<0.05$). Maynard (2015) found large variations in linear measurements that could be a result of goats in different stances and moving while being measured. Additionally, differences when measuring due to variations in locating the specific anatomical parts used in measurements might have added to the overall variation of the measurements.

Table 3. 9. Least square means and mean square error of linear body measurements by treatment

Trait	Control	Deco.[c]	Monensin[d]	MSE	Trait	Control	Deco.[c]	Monensin[d]	MSE
Chine Length, cm					Loin Length, cm				
D 28	16.62	16.95	16.41		D 28	18.65	18.57	18.20	
D 42	17.09	17.05	16.76	0.1907	D 42	18.50	18.77	18.47	0.1446
D 56	17.53	17.40	17.76		D 56	17.70	18.68	18.66	
Rump Length, cm					Heart Girth, cm				
D 28	11.79	11.90	11.81		D 28	70.21	71.06	68.65	
D 42	13.03	13.59	12.94	0.2851	D 42	71.00	72.77	71.77	2.268
D 56	12.09	13.33	12.76		D 56	70.36	72.38	71.86	

(Table Cont'd)

Trait	Control	Deco.[c]	Monensin[d]	MSE	Trait	Control	Deco.[c]	Monensin[d]	MSE
Barrel Circumference, cm					Hip Height, cm				
D 28	82.09	83.87	81.87		D 28	58.63[ab]	60.36[a]	59.58[a]	
D 42	82.22	84.71	81.88	5.119	D 42	59.26[a]	60.78[a]	60.53[a]	0.3132
D 56	81.15	82.03	80.62		D 56	56.87[b]	59.74[a]	58.68[ab]	
Withers Height, cm					Chest Depth, cm				
D 28	61.95[ab]	62.83[a]	61.93[ab]		D 28	26.15	26.74	26.67	
D 42	61.62[ab]	62.99[a]	62.43[a]	0.4806	D 42	26.24	27.14	26.94	0.3465
D 56	59.58[b]	61.04[ab]	61.09[ab]		D 56	26.30	27.27	27.29	
Chest Width, cm					Live Conformation[e], Subjective Score				
D 28	18.06	17.18	17.89		D 28	252	250	245	
D 42	17.80	18.80	18.50	0.3154	D 42	253	245	249	69.29
D 56	17.73	18.42	18.04		D 56	254	262	252	

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] Deco. = decoquinate, concentration 0.025 g/kg
[d] Monensin concentration 0.022 g/kg
[e] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399 with 199 being the ideal market animal and 300 being the least desirable.

The linear measurements by breed are in Table 3.10. There were multiple differences throughout the trial. One would expect that the animal's linear measurements would change over the course of the experiment. Additionally, the animals were visually different in size throughout the experiment. Notably, the heart girth was greater for the Boer-Spanish wethers than the Savanna-Spanish wethers at day 42 and 56. Heart girth has been shown to correlate with the weights of the animals. The other differences indicate that the Boer-Spanish goats were overall a larger goat. Without accurate kidding dates on the goats, it is hard to distinguish if this is due to

the breed differences or the age of the animals. Additionally, the Savannah-Myotonic wethers had a greater conformation score with more muscular features than the Savannah-Spanish wethers throughout the experiment.

Table 3. 10. Least square means and mean square error of linear body measurements by breed

Trait	Breed				Trait	Breed			
	B-S[e]	S-S[f]	S-M[g]	MSE		B-S[e]	S-S[f]	S-M[g]	MSE
Chine Length, cm					Loin Length, cm				
D 28	17.39[ab]	16.18[c]	16.14[c]		D 28	19.06[a]	18.38[ab]	17.60[b]	
D 42	17.49[ab]	16.86[bc]	16.18[bc]	2.0	D 42	18.86[ab]	18.68[ab]	17.93[ab]	1.99
D 56	18.61[a]	17.10[abc]	17.06[abc]		D 56	19.35[a]	18.22[ab]	17.48[b]	
Rump Length, cm					Heart Girth, cm				
D 28	12.32[abc]	11.36[c]	11.73[bc]		D 28	71.37[abc]	66.81[c]	72.14[abc]	
D 42	13.60[a]	12.87[ab]	12.94[ab]	1.7	D 42	73.78[a]	68.46[bc]	73.62[ab]	39.2
D 56	13.63[a]	12.21[abc]	12.28[abc]		D 56	75.95[a]	67.16[bc]	71.54[abc]	
Barrel Circumference, cm					Hip Height, cm				
D 28	83.15	80.45	85.09		D 28	61.88[a]	58.30[bcd]	57.24[cd]	
D 42	82.25	81.15	86.81	46.8	D 42	61.21[ab]	59.91[abc]	58.84[abcd]	13.6
D 56	82.85	78.74	82.30		D 56	61.66[ab]	58.48[abcd]	55.16[d]	
Withers Height, cm					Chest Depth, cm				
D 28	65.56[a]	59.61[c]	60.38[ab]		D 28	27.61[ab]	25.40[c]	26.31[bc]	
D 42	65.20[a]	60.41[bc]	60.29[ab]	14.97	D 42	27.74[ab]	25.59[c]	26.86[abc]	3.68
D 56	64.49[ab]	59.22[c]	58.06[c]		D 56	28.73[a]	25.86[bc]	26.24[bc]	

(Table Cont'd)

Trait	Breed				Trait	Breed			
	B-S[e]	S-S[f]	S-M[g]	MSE		B-S[e]	S-S[f]	S-M[g]	MSE
Chest width, cm					Live Conformation[h], Subjective Score				
D 28	18.48[ab]	17.09[c]	18.72[ab]		D 28	247[ab]	237[a]	271[c]	
D 42	18.71[ab]	17.45[bc]	19.19[a]	2.62	D 42	250[abc]	236[a]	267[bc]	562
D 56	18.35[abc]	17.43[bc]	18.42[abc]		D 56	255[abc]	235[a]	275[c]	

[abcd] Least square means for a trait with different letters are different (P<0.05)
[e] B-S = Boer-Spanish
[f] S-S = Savannah-Spanish
[g] S-M = Savannah-Myotonic
[h] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399 with 199 being the ideal market animal and 300 being the least desirable.

The linear measurements by breed and treatment are in Table 3.11. The interactions show similar findings to those found among the breeds. The differences in the rump length, chest width are seen between days and are expected due to animals growing. The hip height measurements indicate a difference in day 56 control Savannah-Myotonic and the decoquinate Boer-Spanish wethers with the Savannah-Myotonic wethers being shorter. For live conformation scores, the Savannah-Myotonic wethers generally were heavier muscled than the Savannah-Spanish treatment groups.

Table 3. 11. Least square means and mean square error of linear body measurements by treatment and breed

Trait	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monensin[d]: B-S[e]	Monensin[d]: S-S[f]	Monensin[d]: S-M[f]	MSE
Chine Length, cm										
D 28	17.45	16.45	15.45	17.86	16.23	16.46	16.87	15.89	15.45	
D 42	17.58	17.24	16.55	17.32	16.97	16.97	17.58	16.59	15.62	2.11
D 56	18.73	17.40	16.45	18.48	16.64	17.02	18.61	17.27	17.58	
Loin Length, cm										
D 28	19.61	18.35	17.44	18.72	18.51	18.39	18.85	18.26	17.10	
D 42	18.62	18.64	18.12	18.90	18.63	18.80	19.08	18.77	17.02	2.03
D 56	18.73	17.27	17.08	19.49	18.48	17.78	19.81	18.92	17.63	
Rump Length, cm										
D 28	12.12[ab]	11.62[ab]	11.47[ab]	12.67[ab]	10.89[b]	12.14[ab]	12.17[ab]	11.60[ab]	11.64[ab]	
D 42	13.74[ab]	12.60[ab]	12.40[ab]	14.07[a]	13.04[ab]	13.61[ab]	12.98[ab]	12.93[ab]	12.91[ab]	1.74
D 56	13.02[ab]	11.75[ab]	11.49[ab]	14.10[a]	12.64[ab]	13.12[ab]	13.78[ab]	12.26[ab]	12.40[ab]	

(Table Cont'd)

Trait	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monensin[d]: B-S[e]	Monensin[d]: S-S[f]	Monensin[d]: S-M[f]	MSE
Heart Girth, cm										
D 28	73.46	65.98	70.44	72.44	67.06	75.49	68.22	67.31	71.03	
D 42	73.66	66.96	71.97	73.35	69.62	77.27	74.32	68.64	72.22	40.91
D 56	75.12	66.67	69.28	75.50	67.12	75.01	77.22	67.69	71.27	
Barrel Circumference, cm										
D 28	84.20	78.49	83.40	82.78	81.79	90.27	72.47	80.85	82.47	
D 42	82.88	79.31	85.01	81.71	83.31	92.96	82.17	80.49	73.48	47.44
D 56	85.34	77.53	80.58	80.90	79.44	76.78	82.30	79.25	80.98	
Hip Height, cm										
D 28	60.94[ab]	57.69[ab]	56.05[ab]	62.36[a]	59.32[ab]	58.22[ab]	62.36[a]	57.83[ab]	57.62[ab]	
D 42	60.10[ab]	59.28[ab]	57.83[ab]	61.52[ab]	60.42[ab]	59.94[ab]	62.03[ab]	59.97[ab]	58.93[ab]	14.31
D 56	60.13[ab]	57.59[ab]	52.90[b]	62.67[a]	59.37[ab]	56.47[ab]	62.17[ab]	58.48[ab]	56.18[ab]	

(Table Cont'd)

Trait	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monensin[d]: B-S[e]	Monensin[d]: S-S[f]	Monensin[d]: S-M[f]	MSE
Wither Height, cm										
D 28	64.52[ab]	59.88[ab]	60.45[ab]	66.37[a]	60.06[ab]	60.76[ab]	65.79[ab]	58.93[b]	59.99[ab]	
D 42	63.42[ab]	60.33[ab]	60.33[ab]	66.37[a]	60.34[ab]	61.37[ab]	65.99[a]	60.56[ab]	59.35[ab]	15.97
D 56	62.74[ab]	58.29[b]	57.72[b]	64.77[ab]	59.31[ab]	58.34[b]	65.98[ab]	60.07[ab]	58.17[b]	
Chest Depth, cm										
D 28	27.38	24.91	25.73	27.56	25.61	27.12	27.90	25.62	26.20	
D 42	27.29	25.21	25.87	28.01	25.68	28.04	27.92	25.84	26.88	3.87
D 56	27.83	25.33	25.75	29.25	25.70	26.50	29.10	26.55	26.48	
Chest Width, cm										
D 28	18.64[ab]	17.05[b]	18.62[ab]	18.64[ab]	17.22[b]	18.96[ab]	18.27[ab]	16.99[b]	18.63[ab]	
D 42	18.52[ab]	16.78[b]	17.98[ab]	18.74[ab]	17.73[ab]	20.86[a]	18.86[ab]	17.77[ab]	19.02[ab]	2.67
D 56	18.40[ab]	17.25[ab]	17.53[ab]	18.18[ab]	17.63[ab]	19.77[ab]	18.48[ab]	17.40[ab]	18.32[ab]	

(Table Cont'd)

Trait	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monensin[d]: B-S[e]	Monensin[d]: S-S[f]	Monensin[d]: S-M[f]	MSE
Live Conformation, Subjective Score										
D 28	259[ab]	264[ab]	265[ab]	237[a]	244[ab]	286[b]	245[ab]	232[a]	263[ab]	
D 42	260[ab]	242[ab]	255[ab]	242[ab]	233[a]	274[b]	247[ab]	235[a]	273[b]	564
D 56	255[ab]	230[a]	270[b]	262[ab]	245[ab]	284[b]	248[ab]	227[a]	274[b]	

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] Deco. = decoquinate, concentration 0.025 g/kg
[d] Monensin concentration 0.022 g/kg
[e] B-S = Boer-Spanish
[f] S-S = Savannah-Spanish
[g] S-M = Savannah-Myotonic

3.3.3. Rumen Fluid

The pH of the rumen fluid was not different among coccidiostat treatments (Table 3.12). The ruminal pH can range from 5.5 to 7.2 (Church, 1993) so the pH values indicated a normal rumen pH. The decrease of the pH from day 0 to day 34 could be due to the animals consuming more concentrate (Church, 1993). It has also been observed by Yang et al. (2001) that the ruminal pH undergoes diurnal changes based on the time of day. The changes could be due to differences in the timing that rumen fluid was taken with the Day 0 fluid taken late morning and Day 34 taken mid-afternoon.

Table 3. 12. Least square means and mean square error of the rumen fluid pH

Treatment	Day 0	Day 34	MSE
Control	6.78	6.30	
Decoquinate[a]	6.78	6.45	0.05
Monensin[b]	6.67	6.50	

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

Table 3. 13. Least square means and mean square error of VFA concentrations

Treatment	% Acetate Day 0	% Acetate Day 34	% Butyrate Day 0	% Butyrate Day 34	% Propionate Day 0	% Propionate Day 34
Control	67.71	66.21	11.11	11.71	21.18	22.08
Decoquinate[a]	68.93	67.88	11.61	10.79	19.47	21.33
Monensin[b]	68.47	63.50	11.06	8.98	20.48	27.52
MSE	0.2275		0.08459		0.07257	

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

Table 3.13. shows the percent of the major VFAs at the beginning and end of the experiment. There were no differences in the VFA percentages throughout the experiment. The concentration of the VFAs were within the ranges reported by Hadjipanayiotou and Antoniou (1983) in which percent acetate ranged from 59 – 74, percent propionate 15 – 28, and percent butyrate 6 – 14.

Table 3. 14. Least square means and mean square error for changes in VFA concentrations

Treatment	Change in Acetate %	Change in Butyrate %	Change in Propionate %
Control	-1.50	0.60	0.89
Decoquinate[a]	-1.05	-0.82	1.87
Monensin[b]	-4.96	-2.08	7.04
MSE	0.4611	0.06221	0.2741

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

Changes in the percentage of each major VFA are in table 3.14. There were no differences found in the changes of VFA concentrations throughout the experiment. Since a sample of each group was used to gather rumen fluid, there is a possibility that the goats that were randomly sampled were not consuming enough concentrates to alter the rumen VFAs. Some of the animals were observed to prefer the grass to concentrate during feedings. The small number of groups and large variation in rumen composition among goats were contributing factors to nonsignificant differences. However, although not significant, monensin in the diet showed a trend for changing the VFA ratios. Sadjadian et al. (2013) reported significantly decreased ß-hydroxybutyrate with 33 mg/kg monensin sodium fed to dairy goats. ß-hydroxybutyrate is a blood metabolite that is part of the ketone bodies. It is hypothesized that the

increase of propionate, a gluconeogenic precursor, would cause the ß-hydroxybutyrate to decrease (Sadjadian et al., 2013). The present results are not strong enough to back the claim that adding monensin to the diets causes a difference in the VFA's. Increasing the sample size of the experiment would allow for more statistical power to determine this claim.

3.3.4. Fecal Egg Count and FAMACHA scores

The oocytes per gram throughout the experiment and the overall change in the amount of fecal oocyte concentrations are in Table 3.15. There were no differences throughout the experiment. The uneven oocyte load within the animals led to high variation. Kid goats generally build up an immunity about four weeks after exposure. Additionally, most adult animals carry coccidian parasites, but are immune to clinical disease (Metzger, 2018). The different origins of the goats within treatments could have contributed to different levels of resistance to coccidia that would explain the high level of variability seen among animals and treatments. Rotating the animals would have given the goats access to the coccidia oocysts from the animals that were previously in the pasture. The reinfection of the animals could have caused the variations or differences in the numbers of the counts of oocysts.

Table 3. 15. Least square means and mean square errors of fecal egg counts by treatment

Treatment	Day 0	Day 14	Day 28	Day 42	Day 56	Change in FEC
Control	2260	7237	10638	6100	8456	6196
Decoquinate[a]	2521	7764	5175	13806	2152	-369
Monensin[b]	3213	983	334	102	224	-2989
MSE			32452227			30949272

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

The fecal egg counts differed with breed (P<0.05) (Table 3.16). The Savannah-Myotonic wethers had a larger load at the beginning of the study. However, there was a large variation throughout the experiment with increased and decreased levels between collection days.

Table 3. 16. Least square means and mean square errors of fecal egg counts by breed

Breed	Day 0	Day 14	Day 28	Day 42	Day 56	Reduction by Day 42	Reduction by Day 56
B-S[c]	1784.[b]	7810	9657[a]	12585	3165	11067	1127
S-S[d]	1938[b]	4259	176[b]	3447	4790	2063	4006
S-M[e]	5871[a]	1598	1590[b]	2170	568	-4013	-4337
MSE	8073531	147561463	99427374	308428917	74553158	339500244	87855254

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] B-S = Boer-Spanish
[d] S-S = Savannah-Spanish
[e] S-M = Savannah-Myotonic

The fecal egg counts by breed and treatment are in Table 3.17. There were differences on days 0, 28, and 42. The rate of shedding of the oocysts from the animal could have influenced the numbers. The rotation of the goats weekly through the pastures may have contributed to re-infection, which could have increased the variation seen throughout the experiment.

Table 3. 17. Least square means and mean square errors of fecal egg counts by treatment and breed

Treatment: Breed	Day 0	Day 14	Day 28	Day 42	Day 56	Reduction by day 42	Reduction by day 56
Control: Boer-Spanish	339[c]	7120	19555[a]	10467[ab]	7433	10128[ab]	6867
Control: Savannah-Spanish	1707[bc]	11383	4658[ab]	2850[ab]	11300	1436[ab]	10113
Control: Savannah-Myotonic	7738[a]	1908	3317[ab]	3850[ab]	150	-5867[b]	-4150
Decoquinate[c]: Boer-Spanish	2304[bc]	15328	9956[ab]	28544[a]	2633	27009[a]	-274
Decoquinate[c]: Savannah-Spanish	1165[bc]	1100	1469[b]	6606[ab]	1325	8210[ab]	660
Decoquinate[c]: Savannah-Myotonic	5025[abc]	2308	1300[b]	2600[ab]	1167	-2050[ab]	-3833
Monensin[d]: Boer-Spanish	2565[abc]	1733	561[b]	130[b]	363	-2435[b]	-2125
Monensin[d]: Savannah-Spanish	2633[abc]	383	250[b]	71[b]	13	-2579[b]	-1263
Monensin[d]: Savannah-Myotonic	5192[ab]	700	128[b]	60[b]	225	-4470[b]	-4763
MSE	7947863	137457627	78980232	269754513	78439868	290710368	93811418

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] Decoquinate, concentration 0.025 g/kg
[d] Monensin concentration 0.022 g/kg

The FAMACHA scores are in Table 3.18. There were no significant differences with treatment, breed, or interactions. The animals that were scored at a 3 or greater were treated with dewormers. This can explain the overall decrease from the beginning to the end of the study. Following the first harvest, there was an increase in the FAMACHA scores. This may have been due to increased stress on the animals reestablishing the social hierarchy of the pen.

Table 3. 18. Least square means and mean square error of the FAMACHA scores by treatment

Treatment	Day 0	Day 14	Day 28	Day 42	Day 56
Control	2.79	2.51	2.14	2.17	2.76
Decoquinate[a]	3.13	2.42	2.29	2.50	2.82
Monensin[b]	3.13	2.80	2.58	2.44	2.40
MSE	0.056	0.026	0.016	0.021	0.047

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

3.3.5. Carcass Measurements

The carcass measurements by treatment are in Table 3.19. There were no differences in the carcass measurements among the treatments and harvest times for any of the measurements. The variation due to breed types may have increased the overall variation of the measurements. The dressing percentages were greater than McMillin et al. (2013) reported of 48%, but were closer to the reports of 53-57% (Kadim et al., 2003). The increased fat cover due to being finished on grain could lead to greater dressing percentages. Additionally, some of the goats being older could have increased the dressing percentages (Ruvuana et al, 1992). The lower averages from goats in harvest 2 could be a result of the remaining smaller animals reaching the same stage of growth in the additional two weeks as the animals in harvest 1.

Table 3. 19. Least squared means and mean square error of carcass data by treatment

Trait	Harvest 1			Harvest 2			
	Control	Deco.[j]	Monensin	Control	Deco.[j]	Monensin	MSE
pH 0 hr	6.43	6.50	6.55	6.88	6.77	6.73	0.02
pH 3 hr	6.05	5.97	5.97	6.59	6.40	6.36	0.004
pH 24 hr	5.63	5.65	5.63	6.17	6.25	6.24	0.0004
LW[a], kg	29.26	30.98	30.16	26.72	28.91	28.61	4.02
HCW[b], kg	16.75	17.24	17.29	14.57	16.47	15.95	1.33
CCW[c], kg	16.36	16.80	16.79	14.29	15.67	15.77	1.12
DP[d], %	57.05	55.40	57.33	54.47	56.56	55.82	0.54
Cooler shrink, Kg	0.39	0.44	0.50	0.36	0.79	0.32	0.07
Shrink %[e]	2.68	2.31	2.87	2.24	2.19	2.33	0.71
Carcass Conformation[f]	257	271	275	287	101	289	81.4
KPH[g], %	2.92	2.85	3.17	3.21	3.73	3.10	0.22
Fat Score[h]	2.00	1.83	2.08	1.54	1.82	1.60	0.12
Body Wall Thickness, cm	1.53	1.49	1.47	1.45	1.56	1.44	0.02
Circum. at Leg, cm[i]	50.82	50.43	51.19	48.23	50.03	50.37	1.55
Circum. at Tail, cm[i]	52.91	53.32	53.49	51.88	52.48	51.92	1.36
Circum. at Rib, cm[i]	68.23	70.30	69.48	65.38	68.33	67.36	2.30

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	Control	Deco.[j]	Monensin	Control	Deco.[j]	Monensin	MSE
Circum. at Chest, cm[i]	67.53	67.69	68.16	63.00	65.95	66.05	2.74
Length 1st rib to crotch, cm	58.46	60.11	58.53	60.31	61.55	62.27	2.69

[a] LW= Live Weight
[b] HCW = Hot Carcass Weight
[c] CCW = Chilled Carcass Weight
[d] DP = Dressing Percentage calculated as (HCW/LW) * 100
[e] Shrink % = (HCW – CCW)/ HCW * 100
[f] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399
[g] KPH = Kidney, Pelvic, Heart Fat
[h] Subjective fat covering over the ribs and shoulder 0 = none, 3 = completely covered
[i] Circumference at indicated carcass location
[j] Deco. = Decoquinate, concentration 0.025 g/kg
[k] Monensin concentration 0.022 g/kg

The least square means and mean square error of carcass measurements by breed are in Table 3.20. The majority of the multiple differences were in the carcasses from harvest 1 Savannah-Myotonic and Harvest 2 Savannah-Spanish kid goats. The carcass measurements provide indicate that the harvest 1 Savannah-Myotonic were more slaughter conditioned than the harvest 2 Savannah-Spanish groups.

Table 3. 20. Least square means and mean square error of carcass measurements by breed

Trait	Harvest 1			Harvest 2			
	B-S[m]	S-S[n]	S-M[o]	B-S[m]	S-S[n]	S-M[o]	MSE
pH 0 hr	6.52[b]	6.50[b]	6.36[b]	6.70[ab]	6.77[ab]	6.91[a]	0.09
pH 3 hr	5.96[bc]	6.10[b]	5.77[c]	6.33[a]	6.48[a]	6.54[a]	0.04
pH 24 hr	5.62[b]	5.64[b]	5.68[b]	6.13[a]	6.25[a]	6.28[a]	0.02

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	B-S[m]	S-S[n]	S-M[o]	B-S[m]	S-S[n]	S-M[o]	MSE
LW[a], kg	29.38[bc]	27.52[bc]	39.92[a]	31.53[b]	24.91[c]	27.81[bc]	9.21
HCW[b], kg	16.85[b]	15.31[bc]	22.75[a]	17.64[b]	13.42[c]	15.93[bc]	3.71
CCW[c], kg	16.40[b]	14.90[bc]	22.27[a]	17.27[b]	13.14[c]	15.02[bc]	3.42
DP[d], %	57.15[a]	55.58[ab]	56.99[a]	56.01[ab]	53.32[b]	57.54[a]	3.46
Shrink %[e]	2.40	2.89	2.59	2.09	2.22	2.48	0.69
Carcass Conformation[f]	265[a]	263[a]	124[bc]	283[ab]	255[a]	124[c]	652
KPH[g], %	2.64[b]	2.63[b]	5.20[a]	3.13[b]	3.13[b]	3.89_{ab}	0.09
Fat Score[h]	1.92[b]	1.53[b]	3.3[a]	1.67[b]	1.21[b]	2.10[b]	0.27
Body Wall Thickness, cm	1.30[c]	1.49[bc]	2.20[a]	1.32[c]	1.25[c]	1.90[ab]	0.07
Circum. at Leg, cm[i]	51.58[ab]	48.17[bc]	55.00[a]	51.88[ab]	46.40[c]	50.52[b]	5.18
Circum. at Tail, cm[i]	53.86[b]	50.40[bc]	58.30[a]	54.10[ab]	48.07[c]	54.21[a]	5.51
Circum. at Rib, cm[i]	69.09[b]	67.14[bc]	76.54[a]	70.38[b]	63.90[c]	66.75[bc]	6.09
Circum. at Chest, cm[i]	67.86[b]	65.46[bc]	74.38[a]	68.77[b]	61.09[c]	64.96[bc]	7.04
Length 1st rib to crotch, cm	58.79[b]	58.41[b]	61.88[ab]	65.30[a]	60.18[b]	58.32[b]	5.52

[abc] Least square means for a trait with different letters are different (P<0.05)
[d] LW= Live Weight
[e] HCW = Hot Carcass Weight
[f] CCW = Chilled Carcass Weight
[g] DP = Dressing Percentage calculated as (HCW/LW) * 100
[h] Shrink % = (HCW – CCW)/ HCW * 100

[i] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399
[j] KPH = Kidney, Pelvic, Heart Fat
[k] Subjective fat covering over the ribs and shoulder 0 = none, 3 = completely covered
[l] Circumference at indicated carcass location
[m] B-S = Boer-Spanish
[n] S-S = Savannah-Spanish
[o] S-M = Savannah-Myotonic

The carcass measurements for the two harvests by breed and treatment are in Table 3.21. There are some differences seen throughout the measurements. The overall differences indicate that the decoquinate Savannah-Myotonic wethers from harvest 1 had more desirable carcass traits than the Savannah-Spanish wethers in harvest 2.

Table 3. 21. Least square means and mean square error of carcass measurements by treatment and breed

Trait	Harvest 1									
	Control: B-S[p]	Control: S-S[q]	Control: S-M[r]	Deco.[s]: B-S[p]	Deco.[s]: S-S[q]	Deco.[s]: S-M[r]	Monen.[t]: B-S[p]	Monen.[t]: S-S[q]	Monen.[t]: S-M[r]	MSE
pH 0 hr	6.34	6.46	6.61	6.61	6.47	6.22	6.62	6.55	6.12	0.10
pH 3 hr	6.03[def]	6.15[bcdef]	5.95[def]	6.04[def]	6.04[def]	5.61[f]	5.86[ef]	6.13[cdef]	5.76[ef]	0.03
pH 24 hr	5.61[e]	5.63[e]	5.68[de]	5.64[e]	5.66[e]	5.67[de]	5.62[e]	5.64[e]	5.69[cde]	0.02
LW[g], kg	29.41[bcd]	25.74[bcd]	35.83[abc]	28.43[bcd]	28.69[bcd]	44.00[a]	30.32[bcd]	28.12bcd	39.92[ab]	8.24
HCW[h], kg	17.18[bcd]	14.34[bcd]	20.25[abc]	15.62[bcd]	15.85[bcd]	25.24[a]	17.74[bcd]	15.75[bcd]	22.77[ab]	2.96
CCW[i], kg	16.74[bc]	14.03[bc]	19.87[ab]	15.23[bc]	15.40[bc]	24.72[a]	17.24[abc]	15.27[bc]	22.18[ab]	3.53
DP[j], %	58.28[ab]	55.41[ab]	57.05[ab]	54.55[ab]	55.41[ab]	57.35[ab]	58.69[ab]	55.91[ab]	57.35[ab]	2.91
Shrink %[k]	2.53	3.09	2.32	2.19	2.40	2.47	2.48	3.23	3.40	0.73
Carcass Conformation[l]	242[a]	270[abc]	115[bc]	278[abc]	266[abc]	120[bc]	275[abc]	252[ab]	120[bc]	667
KPH[m], %	2.58[ab]	2.75[ab]	4.25[ab]	2.17[b]	2.46[ab]	6.00[a]	3.17[ab]	2.67[ab]	5.50[ab]	0.77
Fat Score[n]	2.00[ab]	1.63[ab]	2.75[ab]	1.58[ab]	1.42[ab]	3.50[a]	2.17[ab]	1.54[ab]	4.00[a]	0.31

(Table Cont'd)

Trait	Harvest 1									
	Control: B-S[p]	Control: S-S[q]	Control: S-M[r]	Deco.[s]: B-S[p]	Deco.[s]: S-S[q]	Deco.[s]: S-M[r]	Monen.[t]: B-S[p]	Monen.[t]: S-S[q]	Monen.[t]: S-M[r]	MSE
Body Wall Thickness, cm	1.31[ab]	1.66[ab]	1.91[ab]	1.22[b]	1.46[ab]	2.40[a]	1.38[ab]	1.36[ab]	2.39[ab]	0.07
Circum. at Leg, cm[o]	52.90[ab]	47.08[bc]	52.05[abc]	49.25[bc]	48.47[bc]	58.15[a]	52.58[abc]	48.96[bc]	54.60[ab]	3.08
Circum. at Tail, cm[o]	54.75[ab]	48.93[b]	55.35[ab]	52.58[ab]	50.59[b]	61.10[a]	54.23[ab]	51.69[ab]	58.60[ab]	5.51
Circum. at Rib, cm[o]	68.40[bc]	65.00[bc]	74.15[ab]	68.83[bc]	68.26[bc]	80.10[a]	68.40[bc]	65.00[bc]	74.15[ab]	4.77
Circum. at Chest, cm[o]	68.43[abc]	63.95[bc]	72.00[ab]	66.52[abc]	65.45[bc]	77.15[a]	68.62[abc]	66.98[abc]	73.60[ab]	6.89
Length 1[st] rib to crotch, cm	57.25	58.50	62.00	59.95	59.06	63.60	59.17	57.66	58.20	5.98

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[p]	Control: S-S[q]	Control: S-M[r]	Deco.[s]: B-S[p]	Deco.[s]: S-S[q]	Deco.[s]: S-M[r]	Monen.[t]: B-S[p]	Monen.[t]: S-S[q]	Monen.[t]: S-M[r]	MSE
pH 0 hr	6.88	6.81	6.96	6.63	6.84	6.87	6.59	6.67	6.91	0.10
pH 3 hr	6.45[abc]	6.72[a]	6.59[ab]	6.36[abcd]	6.42[abcd]	6.44[abcd]	6.19[bcde]	6.32[abcd]	6.55[ab]	0.03
pH 24 hr	6.09[bcd]	6.31[abc]	6.11[abc]	6.28[ab]	6.24[abc]	6.23[abc]	6.02[bcd]	6.22[abc]	6.43[a]	0.02
LW[g], kg	31.98[bcd]	23.13[d]	25.06[cd]	31.07[bcd]	24.95[cd]	30.84[bcd]	31.52[bcd]	26.65[bcd]	27.52[bcd]	8.24
HCW[h], kg	18.05[bcd]	12.37[d]	13.94[cd]	17.49[bcd]	13.76[cd]	18.40[abcd]	18.05[bcd]	14.13[cd]	15.46[bcd]	2.96
CCW[i], kg	17.03[bc]	12.09[c]	13.76[bc]	17.12[abc]	13.45[bc]	15.79[bc]	17.67[abc]	13.88[bc]	15.51[bc]	3.53
DP[j], %	54.45[ab]	53.32[ab]	55.65[ab]	56.34[ab]	53.99[ab]	59.97[a]	57.25[ab]	57.66[b]	57.02[ab]	2.91
Shrink %[k]	2.09	2.33	2.30	2.07	2.51	1.92	2.11	3.23	3.07	0.73
Carcass Conformation[l]	285[abc]	256[abc]	110[bc]	287[abc]	255[abc]	130[c]	275[abc]	254[ab]	108[bc]	667
KPH[m], %	3.25[ab]	2.75[ab]	3.63[ab]	2.75[ab]	3.50[ab]	5.25[ab]	3.38[ab]	3.13[ab]	2.79[ab]	0.77
Fat Score[n]	1.50[ab]	1.13[b]	2.00[ab]	1.63[ab]	1.38[ab]	2.63[ab]	1.88[ab]	1.13[b]	1.67[ab]	0.31
Body Wall Thickness, cm	1.23[b]	1.36[ab]	1.75[ab]	1.34[ab]	1.34[ab]	2.18[ab]	1.40[ab]	1.05[b]	1.77[ab]	0.07

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[p]	Control: S-S[q]	Control: S-M[r]	Deco.[s]: B-S[p]	Deco.[s]: S-S[q]	Deco.[s]: S-M[r]	Monen.[t]: B-S[p]	Monen.[t]: S-S[q]	Monen.[t]: S-M[r]	MSE
Circum. at Leg, cm[o]	51.69[abc]	45.53[c]	47.50[bc]	51.69[abc]	45.91[bc]	53.34[ab]	52.26[abc]	47.75[bc]	50.74[bc]	3.08
Circum. at Tail, cm[o]	53.78[ab]	47.56[b]	54.29[ab]	53.66[ab]	48.45[b]	56.26[ab]	54.86[ab]	48.20[b]	52.09[ab]	5.51
Circum. at Rib, cm[o]	69.79[bc]	61.98[c]	64.39[bc]	70.99[b]	64.77[bc]	69.28[bc]	70.36[bc]	64.96[bc]	66.57[bc]	4.77
Circum. at Chest, cm[o]	67.88[abc]	59.12[c]	61.98[bc]	68.96[abc]	61.53[bc]	67.31[abc]	69.47[abc]	62.61[bc]	65.60[bc]	6.89
Length 1st rib to crotch, cm	65.47	57.53	57.91	64.71	60.33	58.04	65.72	62.67	59.01	5.98

[abcef] Least square means for a trait with different letters are different (P<0.05)
[g] LW= Live Weight
[h] HCW = Hot Carcass Weight
[i] CCW = Chilled Carcass Weight
[j] DP = Dressing Percentage calculated as (HCW/LW) * 100
[k] Shrink % = (HCW – CCW)/ HCW * 100
[l] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399
[m] KPH = Kidney, Pelvic, Heart Fat
[n] Subjective fat covering over the ribs and shoulder 0 = none, 3 = completely covered
[o] Circumference at indicated carcass location
[p] B-S = Boer-Spanish
[q] S-S = Savannah-Spanish
[r] S-M = Savannah-Myotonic
[s] Deco. = Decoquinate, concentration 0.025 g/kg
[t] Monen. = Monensin concentration 0.022 g/kg

Table 3.22 shows the objective flank color and the subjective carcass flank scores. There were statistical differences among the treatment and harvest combinations. Most notably, the carcasses from the second harvest monensin group had greater (P<0.05) a* values than those from the first harvest decoquinate value. Goat meat color has been reported to range from L* 45.26 – 48.79, a* 10.05 – 12.11, and b* 0.95 – 2.57 (Yalcitan et al., 2018). The values were similar to these finding. There was some variation that can be due to breed (Yalcitan et al., 2018). The interaction of coccidiostat treatments and breeds was not significant on the analytical readings.

Table 3. 22. Least square means and mean square error of flank color (*M. Rectus abdominis*) by treatment

Trait	Harvest 1			Harvest 2			
	Control	Decoquinate[c]	Monensin[d]	Control	Decoquinate[c]	Monensin[d]	MSE
Flank Color[e]							
L*	45.23[ab]	48.65[a]	44.22[b]	44.52[b]	44.13[b]	44.76[ab]	1.023
a*	12.71[ab]	11.02[b]	13.11[ab]	13.29[ab]	13.35[ab]	13.44[a]	0.3482
b*	-2.76	-3.45	-2.39	-2.89	-1.56	-2.93	0.4980
Flank Color Score[f]							
	205	207	206	191	200	209	132

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] Decoquinate concentration 0.025 g/kg
[d] Monensin concentration 0.022 g/kg
[e] L* 0 = black, 100 = white; a* -value = green, +value = red; b* -value = blue, +value = yellow
[f] 100 = light pink, 200 = reddish pink, 300 = red

The objective flank color score by breed is in Table 3.23. The harvest 2 Savanna-Spanish wethers had lighter flank color scores than harvest 1 Boer-Spanish wethers. Goats with lighter muscles are generally seen as younger animals (Kannan et al., 2003).

Table 3. 23. Least square means and mean square error of flank color score (*M. Rectus abdominis*) by breed

Trait	Harvest 1			Harvest 2			
	B-S[d]	S-S[e]	S-M[f]	B-S[d]	S-S[e]	S-M[f]	MSE
Flank Color Score[c]	216[a]	195[ab]	200[ab]	214[ab]	184[b]	200[ab]	299

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] 100 = light pink, 200 = reddish pink, 300 = red
[d] B-S = Boer-Spanish
[e] S-S = Savannah-Spanish
[f] S-M = Savannah-Myotonic

The least square means and the means square error for the *M. Longissimus dorsi* rib eye measurements are in Table 3.24. There were no differences in the rib eye areas among treatments or harvest times. The rib eye averages were larger than those previously reported of 10.7 cm^2 for goats raised on intensive grazing systems (Johnson et al., 1998; Johnson et al., 1995). The animals' carcass weights were heavier than those reported in the other studies. This reflects the greater dressing percentages in this study, but may also be due to the breeds used or differences in slaughter age.

Table 3. 24. Least square means and means square error of rib eye area (cm^2) measurements by treatment

Trait	Harvest 1			Harvest 2			
	Control	Decoquinate[a]	Monensin[b]	Control	Decoquinate[a]	Monensin[b]	MSE
Left rib eye	12.02	10.66	12.36	11.08	12.27	11.69	0.4384
Right rib eye	11.61	11.47	12.19	10.78	12.09	12.11	0.9503
Avg. rib eye	11.81	11.06	12.27	11.03	12.17	11.90	0.6016

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg

The rib eye area (cm^2) by breed are in Table 3.25. Harvest 2 Boer-Spanish wethers had a larger rib eye than Savannah-Spanish wethers in both harvest groups. which coincided with the heavier carcass weights of Boer-Spanish wether carcasses than Savannah-Spanish wether carcasses.

Table 3. 25. Least square means and means square error of rib eye area (cm^2) measurements by breed

Trait	Harvest 1			Harvest 2			
	B-S[c]	S-S[d]	S-M[e]	B-S[c]	S-S[d]	S-M[e]	MSE
Left Rib eye	12.56[ab]	10.00[b]	13.03[ab]	13.61[a]	9.92[b]	11.61[ab]	5.42
Right rib eye	12.81[ab]	9.87[b]	13.15[ab]	13.77[a]	10.02[b]	11.54[ab]	6.20
Avg. rib eye	12.68[ab]	9.94[b]	13.09[ab]	13.69[a]	9.97[b]	11.58[ab]	5.15

[ab] Least square means with different letters are different ($P<0.05$)
[c] B-S = Boer-Spanish
[d] S-S = Savannah-Spanish
[e] S-M = Savannah-Myotonic

The rib eye area by treatment and breed are in table 3.26. Similar differences are seen as that of the breeds. Harvest 2 control Savannah-Myotonic groups eyes were smaller than harvest 1 decoquinate Savannah-Myotonic group. Additionally, the all of the Savannah-Spanish average rib eye areas were smaller than the average harvest 1 decoquinate Savannah-Myotonic goats rib eye areas.

Table 3. 26. Least square means and means square error of rib eye area (cm^2) measurements by breed and treatment

Trait	Harvest 1									
	Control: B-S[c]	Control: S-S[d]	Control: S-M[e]	Deco.[a]: B-S[c]	Deco.[a]: S-S[d]	Deco.[a]: S-M[e]	Monen.[b]: B-S[c]	Monen.[b]: S-S[d]	Monen.[b]: S-M[e]	MSE
Left rib eye	13.88[fg]	9.45[h]	11.58[fgh]	10.47[gh]	9.30[h]	14.77[f]	13.34[fg]	11.15[fgh]	12.47[fgh]	4.82
Right rib eye	13.08[fg]	9.37[h]	11.63[fgh]	12.03[fgh]	9.62[h]	14.27[f]	13.31[fg]	10.51[gh]	13.93[fg]	6.86
Avg. rib eye area	13.48[fg]	9.41[h]	11.61[fgh]	11.25[fgh]	9.46[h]	14.62[f]	13.32[fg]	10.83[gh]	13.20[fg]	5.22
Trait	Harvest 2									
	Control: B-S[c]	Control: S-S[d]	Control: S-M[e]	Deco.[a]: B-S[c]	Deco.[a]: S-S[d]	Deco.[a]: S-M[e]	Monen.[b]: B-S[c]	Monen.[b]: S-S[d]	Monen.[b]: S-M[e]	MSE
Left rib eye	13.10[fg]	10.09[gh]	10.06[gh]	14.69[f]	9.13[h]	14.03[f]	13.31[fg]	10.55[gh]	11.41[fgh]	4.82
Right rib eye	13.73[fg]	9.22[h]	9.97[h]	13.47[fh]	10.08[gh]	13.02[fg]	14.04[f]	10.74[gh]	11.90[fgh]	6.86
Avg. rib eye area	13.42[fg]	9.66[h]	10.02[gh]	14.08[f]	9.60[h]	13.53[fg]	13.68[fg]	10.65[gh]	11.65[fgh]	5.22

[fgh]Least squares means with different letters are different (P<0.05)
[a] Deco. = decoquinate concentration 0.025 g/kg
[b] Monen. = monensin concentration 0.022 g/kg
[c] B-S = Boer-Spanish
[d] S-S = Savannah-Spanish
[e] S-M = Savannah-Myotonic

The carcass cut weights in grams by treatments are in Table 3.27. There were no differences in any of the weights of the cuts among the dietary treatments or within harvest time. Table 3.28 has the carcass cut weights in grams by breed. The results show that harvest 1 Savannah-Myotonic goats had greater cut weights than the Savannah-Spanish goats from harvest 2. This is to be expected since the Savannah-Myotonic goats had overall heavier carcasses than the Savannah-Spanish goats, as was previously mentioned.

Table 3. 27. Least squared means and mean squared error of carcass cut weights (g) by treatment

Trait	Harvest 1			Harvest 2			
	Control	Deco.[a]	Monensin[b]	Control	Deco.[a]	Monensin[b]	MSE
CCSW[c]	16425.42	16965.96	16911.67	14465.50	16645.50	14851.43	3242204
KPH[d]	696.33	780.44	752.83	571.08	703.36	519.71	19038
Foreleg	1533.42	1614.94	1566.67	1284.67	1528.61	1331.57	29461
Foreleg Trot Off	1450.58	1520.65	1481.25	1210.50	1447.86	1257.43	27509
Foreleg Shank Off	1151.50	1209.78	1182.83	943.00	1148.84	974.07	20233
Foreleg Trotter	82.83	94.69	85.59	73.17	80.30	73.50	48.62
Foreleg Shank	299.08	310.88	297.67	267.08	299.46	283.71	682.5
Boneless Foreleg	758.08	758.03	780.25	601.17	719.32	648.29	10485
Shoulder	1407.75	1394.60	1457.42	1373.08	1476.46	1419.14	21462
Neck Off	954.00	978.15	1057.17	1033.42	1097.25	1048.64	13332
Neck	454.00	416.65	400.50	339.25	380.55	370.21	1984

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	Control	Deco.[a]	Monensin[b]	Control	Deco.[a]	Monensin[b]	MSE
Boneless Shoulder	476.92	470.76	469.75	465.00	504.23	466.86	1706.8
Ribs Whole	846.92	911.66	892.75	827.33	916.52	811.57	9481
Ribs Trimmed	655.25	699.09	706.17	667.83	775.07	669.64	7140
Rear Leg	2093.83	2074.13	2117.25	1938.67	2194.43	2018.36	54501
Rear Leg Trot Off	1981.58	1950.50	2000.08	1838.50	2087.50	1915.57	50974
Rear Leg Shank Off	1669.83	1630.71	1686.58	1591.58	1804.59	1656.57	43810
Rear Leg Trotter	112.50	123.56	117.33	99.25	106.68	102.14	126.1
Rear Leg Shank	311.58	319.94	313.50	247.25	282.50	257.71	526.3
Boneless Rear Leg	1151.50	1122.81	1168.00	1052.42	1268.88	1125.93	13612
Back/ Loin	1894.00	1892.84	1939.83	1581.42	1830.43	1564.21	46873
Backstrip	918.83	891.46	906.67	804.83	1000.68	843.93	14187
Back-lip Off	596.42	599.18	583.25	540.00	690.95	566.21	6122
Tenderloin	96.33	97.16	95.33	78.25	96.18	86.79	102.8

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	Control	Deco.[a]	Monensin[b]	Control	Deco.[a]	Monensin[b]	MSE
Semi.[e]	377.17	372.99	364.92	300.25	343.43	294.50	893
Boneless lean[f]	3431.82	3108.07	3366.18	3002.46	3436.11	3251.36	549840

[a] Decoquinate concentration 0.025 g/kg
[b] Monensin concentration 0.022 g/kg
[c] CCSW= Cold Carcass Side Weight
[d] KPH= Kidney, Pelvic, and Heart Fat
[e] Semi. = *M. Semimembranosus*
[f] Total boneless lean = Boneless Foreleg + Boneless Shoulder + Backstrip + Boneless Rear Leg

Table 3. 28. Least squared means and mean squared error of carcass cut weights (g) by breed

Trait	Harvest 1			Harvest 2			
	B-S[d]	S-S[e]	S-M[f]	B-S[d]	S-S[e]	S-M[f]	MSE
CCSW[g]	16502.22[bc]	15033.07[bc]	22311.40[a]	17412.25[b]	13299.33[c]	15928.42[bc]	9286550
KPH[h]	601.61[b]	698.71[b]	1439.60[a]	635.33[b]	509.00[b]	607.75[b]	76785.06
Foreleg	1606.94[ab]	1348.50[bc]	1933.40[a]	1581.83[ab]	1243.42[c]	1423.00[bc]	68361.50
Foreleg Trot Off	1516.33[ab]	1268.43[bc]	1835.60[a]	1490.67[ab]	1172.08[c]	1351.92[bc]	64317.12
Foreleg Shank Off	1216.94[ab]	984.00[c]	1478.60[a]	1161.50[abc]	914.92[c]	1064.67[bc]	45267.77
Foreleg Trotter	90.72[a]	79.79[ab]	97.80[a]	91.08[a]	70.50[b]	70.58[b]	202.50
Foreleg Shank	299.28[ab]	284.36[ab]	355.40[a]	330.17[a]	257.50[b]	286.67[ab]	2872.29
Boneless Foreleg	767.50[ab]	674.21[bc]	933.80[a]	737.25[abc]	594.83[c]	682.92[bc]	20857.44
Shoulder	1384.11[b]	1322.43[b]	1912.20[a]	1523.00[ab]	1256.75[b]	1526.50[ab]	110112.50
Neck Off	960.44[b]	946.21[b]	1411.20[a]	1105.25[ab]	892.83[b]	1173.83[ab]	79261.78
Neck	423.89[ab]	376.71[ab]	501.80[a]	418.50[ab]	363.42[b]	352.08[b]	7130.39
Boneless Shoulder	475.17[ab]	431.07[b]	642.00[a]	533.00[ab]	378.42[b]	516.42[ab]	17228.50
Ribs Whole	787.28[b]	826.36[b]	1396.20[a]	894.00[b]	741.25[b]	952.42[b]	45055.21

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	B-S[d]	S-S[e]	S-M[f]	B-S[d]	S-S[e]	S-M[f]	MSE
Ribs Trimmed	596.11[c]	657.86[bc]	1097.60[a]	736.83[bc]	604.50[bc]	793.08[b]	30767.05
Rear Leg	2140.72[ab]	1857.64[bc]	2596.20[a]	2425.33[a]	1736.25[c]	2081.25[abc]	131577.70
Rear Leg Trot Off	2022.17[ab]	1751.36[bc]	2457.60[a]	2305.75[a]	1634.08[a]	1980.50[abc]	119616.10
Rear Leg Shank Off	1696.83[ab]	1468.86[b]	2100.80[a]	2009.33[a]	1368.17[b]	1727.42[ab]	97988.03
Rear Leg Trotter	118.83[ab]	106.07[b]	138.60[a]	118.42[ab]	102.00[b]	100.42[b]	450.31
Rear Leg Shank	325.44[a]	28.57[ab]	356.40[a]	296.00[ab]	264.75[ab]	253.08[b]	4134.30
Boneless Rear Leg	1181.22[ab]	1007.64[bc]	1427.80[a]	1359.75[a]	920.75[c]	1207.17[ab]	52574.53
Back/ Loin	1922.83[ab]	1677.07[bc]	2441.40[a]	1864.75[ab]	1408.33[c]	1756.33[bc]	141301.30
Backstrip	914.22[bc]	811.64[bc]	1218.60[a]	991.00[ab]	727.08[c]	912.58[bc]	38914.17
Back-lip Off	608.50[abc]	538.14[bc]	801.00[a]	675.17[ab]	452.75[c]	631.42[abc]	22447.00
Tenderloin	99.83[a]	86.14[ab]	118.20[a]	95.00[ab]	69.92[b]	97.33[ab]	605.89
Semi.[i]	381.22[b]	316.86[bc]	490.80[a]	368.75[b]	263.58[c]	317.92[bc]	5090.23
Boneless Lean[j]	3132.22[ab]	2737.21[bc]	3922.80[a]	3400.17[ab]	2416.67[c]	3135.25[ab]	339632.20

[abc] Least square means for a trait with different letters are different (P<0.05)
[d] B-S = Boer-Spanish
[e] S-S = Savannah-Spanish
[f] S-M = Savannah-Myotonic

[g] CCSW= Cold Carcass Side Weight
[h] KPH= Kidney, Pelvic, and Heart Fat
[i] Semi. = *Semimembranosus*
[j] Total boneless lean = Boneless Foreleg + Boneless Shoulder + Backstrip + Boneless Rear Leg

Table 3. 29. Least squared means and mean squared error of carcass cut weights (g) by breed and treatment

Trait	Harvest 1									
	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monen.[d]: B-S[e]	Monen.[d]: S-S[f]	Monen.[d]: S-M[g]	MSE
CCSW[h]	16821[ab]	14369[b]	19915[ab]	15305[b]	14616[b]	24748[a]	17381[ab]	15981[ab]	22232[ab]	9851386
KPH[i]	574[b]	689[b]	1311[ab]	610[b]	613[b]	1668[a]	620[b]	792[ab]	1605[ab]	83628
Foreleg	1622[ab]	1275[ab]	1746[ab]	1525[ab]	1376[ab]	2095[a]	17673[ab]	1379[ab]	1985[ab]	72921
Foreleg Trot Off	1534[ab]	1198[ab]	1666[ab]	1431[ab]	1296[ab]	1983[a]	1584[ab]	1297[ab]	1881[ab]	68593
Foreleg Shank Off	1225[ab]	929[ab]	1327[ab]	1143[ab]	1002[ab]	1614[a]	1282[ab]	1010[ab]	1512[ab]	47657
Foreleg Trotter	88[ab]	76[ab]	81[ab]	95[ab]	80[ab]	112[a]	90[ab]	82[ab]	105[ab]	208
Foreleg Shank	309	269	340	288	294	369	301	287	360	3107

(Table Cont'd)

Trait	Harvest 1									
	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monen.[d]: B-S[e]	Monen.[d]: S-S[f]	Monen.[d]: S-M[g]	MSE
Boneless Foreleg	810	610	893	693	667	997	800	733	890	220059
Shoulder	1517[ab]	1271[ab]	1649[ab]	1172[b]	1256[ab]	2178[a]	1464[ab]	1430[ab]	1908[ab]	109581
Neck Off	1034	952	1156	800	874	1636	1047	1014	1472	81564
Neck	483	321	493	372	382	543	417	416	437	6719
Boneless Shoulder	514	440	638	411	410	697	500	446	541	16957
Ribs Whole	789[b]	803[b]	1208[ab]	698[b]	837[b]	1539[a]	875[b]	836[b]	1488[ab]	47856
Ribs Trimmed	605[b]	656[b]	692[ab]	514[b]	632[b]	1224[a]	700[b]	686[ab]	1116[ab]	32115
Rear Leg	2254[ab]	1815[ab]	2325[ab]	1953[ab]	1747[ab]	2868[a]	2216[ab]	2002[ab]	2597[ab]	136533
Rear Leg Trot Off	2138[ab]	1722[ab]	2206[ab]	1832[ab]	1641[ab]	2711[a]	2096[ab]	1885[ab]	2454[ab]	123841
Rear Leg Shank Off	1809[ab]	1472[ab]	1911[ab]	1524[ab]	1348[ab]	2263[a]	1758[ab]	1587[ab]	2156[ab]	102215

(Table Cont'd)

Trait	Harvest 1									
	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monen.[d]: B-S[e]	Monen.[d]: S-S[f]	Monen.[d]: S-M[g]	MSE
Rear Leg Trotter	116[ab]	93[ab]	119[ab]	121[ab]	106[ab]	157[a]	120[ab]	117[ab]	143[ab]	455
Rear Leg Shank	329[ab]	250[ab]	295[ab]	309[ab]	293[ab]	448[a]	338[ab]	298[ab]	298[ab]	3922
Boneless Rear Leg	1273[ab]	1013[ab]	1339[ab]	1048[ab]	924[b]	1532[a]	1223[ab]	1087[ab]	1397[ab]	50199
Back/ Loin	1954	1661	2317	1780	1652	2526	2034	1715	2523	157718
Backstrip	979	876	1119	818	742	1307	946	829	1243	40412
Back-lip Off	646	610	749	561	472	873	618	546	762	23128
Tenderloin	105	90	124	95	82	111	100	88	122	692
Semi.[j]	411[ab]	314[ab]	466[ab]	353[ab]	286[b]	538[a]	380[ab]	351[ab]	447[ab]	5460
Boneless Weight[k]	3348[ab]	2763[ab]	3742[ab]	2809[ab]	2555[ab]	4209[a]	3240[ab]	2899[ab]	3712[ab]	339706

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monen.[d]: B-S[e]	Monen.[d]: S-S[f]	Monen.[d]: S-M[g]	MSE
CCSW[h]	17173[ab]	12822[b]	13921[b]	17232[ab]	13899[b]	18253[ab]	17832[ab]	13178[b]	16140[ab]	9851386
KPH[i]	628[b]	569[b]	535[b]	616[b]	516[b]	760[ab]	663[b]	443[b]	575[b]	83628
Foreleg	1506[ab]	1266[ab]	1243[ab]	1650[ab]	1270[ab]	1654[ab]	1590[ab]	1195[b]	1429[ab]	72922
Foreleg Trot Off	1411[ab]	1193[ab]	1182[ab]	1561[ab]	1205[ab]	1578[ab]	1500[ab]	1119[b]	1353[ab]	68594
Foreleg Shank Off	1074[ab]	927[ab]	948[ab]	1238[ab]	955[ab]	1265[ab]	1173[ab]	863[b]	1038[ab]	47657
Foreleg Trotter	94[ab]	73[ab]	61[b]	88[ab]	65[b]	76[ab]	91[ab]	74[ab]	75[ab]	208
Foreleg Shank	337	266	234	325	250	312	328	266	314	3107
Boneless Foreleg	675	591	632	731	636	779	807	558	666	220060
Shoulder	1630[ab]	1091[b]	1370[ab]	1375[ab]	1248[ab]	1701[ab]	1564[ab]	1432[ab]	1547[ab]	109582
Neck Off	1192	782	1062	977	881	1295	1147	1016	1191	81564
Neck	438	308	308	400	367	406	418	416	355	6720

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monen.[d]: B-S[e]	Monen.[d]: S-S[f]	Monen.[d]: S-M[g]	MSE
Boneless Shoulder	586	340	456	406	412	631	608	384	496	16958
Ribs Whole	902[ab]	682[b]	870[b]	879[ab]	823[b]	1126[ab]	901[ab]	719[b]	915[ab]	4787
Ribs Trimmed	711[ab]	578[b]	705[ab]	733[ab]	668[b]	956[ab]	767[ab]	568[b]	766[ab]	32115
Rear Leg	2373[ab]	1601[b]	1835[ab]	2449[ab]	1820[ab]	2277[ab]	2455[ab]	1788[ab]	2160[ab]	136534
Rear Leg Trot Off	2250[ab]	1506[b]	1750[ab]	2328[ab]	1719[ab]	2066[ab]	2340[ab]	1678[ab]	2054[ab]	123842
Rear Leg Shank Off	1983[ab]	1235[b]	1525[ab]	2015[ab]	1415[ab]	1914[ab]	2031[ab]	1455[ab]	1778[ab]	102215
Rear Leg Trotter	123[ab]	94[ab]	85[b]	120[ab]	102[ab]	112[ab]	113[ab]	111[ab]	106[ab]	455
Rear Leg Shank	267[ab]	271[ab]	226[b]	313[ab]	303[ab]	252[ab]	308[ab]	220[b]	276[ab]	3922
Boneless Rear Leg	1327[ab]	841[b]	1003[ab]	1351[ab]	943[ab]	1507[a]	1402[ab]	978[ab]	1190[ab]	50199

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[e]	Control: S-S[f]	Control: S-M[g]	Deco.[c]: B-S[e]	Deco.[c]: S-S[f]	Deco.[c]: S-M[g]	Monen.[d]: B-S[e]	Monen.[d]: S-S[f]	Monen.[d]: S-M[g]	MSE
Back/ Loin	1924	1397	1544	1813	1483	2063	1857	1346	1742	157718
Backstrip	1011	692	746	990	764	1087	972	725	941	40412
Back-lip Off	686	454	484	667	486	751	673	419	677	23128
Tenderloin	92	71	82	93	74	108	100	65	104	692
Semi.[j]	387[ab]	250[b]	283[b]	370[ab]	283[b]	337[ab]	350[ab]	258[b]	335[ab]	5460
Boneless Weight[k]	3366[ab]	2297[b]	2657[ab]	3247[ab]	2550[ab]	3777[ab]	3589[ab]	2404[ab]	3133[ab]	339706

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] Deco. = decoquinate concentration 0.025 g/kg
[d] Monen. = monensin concentration 0.022 g/kg
[e] B-S = Boer-Spanish
[f] S-S = Savannah-Spanish
[g] S-M = Savannah-Myotonic
[h] CCSW= Cold Carcass Side Weight
[i] KPH= Kidney, Pelvic, and Heart Fat
[j] Semi. = *Semimembranosus*
[k] Total boneless lean = Boneless Foreleg + Boneless Shoulder + Backstrip + Boneless Rear Leg

The cuts as a percentage of the cold carcass weight are in Table 3.30. The percentage of the rear leg and the rear leg without the trotter was a greater percentage of the carcass for the goats in monensin diet harvest 2 than in the goats from all treatments for the first harvest ($p<0.05$). The percentage of the right leg with shank removed for the control and monensin treatments for harvest 2 were greater than for all of the treatments for the first harvest ($P<0.05$). The boneless rear leg percentage for goats in the decoquinate treatment harvest 2 was greater than for the goats in decoquinate treatment harvest 1. The back/loin percentages of the goats in control and monensin harvest 1 were greater than for the monensin treatment harvest 2 group ($P<0.05$). The loin without the lip percentage was greater for goats in the control treatment harvest 1 and monensin harvest 2 ($P<0.05$). The differences in the percentages for the rear leg and back/loin percentages may be due to animals gaining weight from anterior to posterior. The increased age may have allowed the goats to change the additional muscling to change the percentages. The other cut percentages were not different with dietary treatments or harvest times. When compared to the values reported by Maynard (2015), the KPH and the back/loin values were greater while the shoulder and hind leg percentages were lower in the present study.

Table 3. 30. Least squared means and mean squared error of carcass cuts as a percent of the cold carcass weight by treatment

Trait	Harvest 1			Harvest 2			
	Control	Deco.[e]	Monensin[f]	Control	Deco.[e]	Monensin[f]	MSE
KPH[g]	4.23	4.60	4.45	3.94	4.15	3.46	0.22
Foreleg	9.33	9.52	9.28	8.88	9.18	8.93	0.05
Foreleg Trot Off	8.83	8.96	8.78	8.37	8.70	8.43	0.06

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	Control	Deco.[e]	Monensin[f]	Control	Deco.[e]	Monensin[f]	MSE
Foreleg Shank Off	7.01	7.13	7.01	6.51	6.89	6.52	0.07
Foreleg Trotter	0.51	0.56	0.51	0.51	0.49	0.50	0.0009
Foreleg Shank	1.82	1.83	1.76	1.85	1.81	1.91	0.007
Boneless Foreleg	4.61	4.47	4.62	4.15	4.29	4.35	0.04
Shoulder	8.57	8.21	8.61	9.48	8.95	9.60	0.34
Neck Off	5.81	5.76	6.23	7.13	6.64	7.11	0.20
Neck	2.77	2.45	2.38	2.34	2.32	2.49	0.06
Boneless Shoulder	2.90	2.77	2.79	3.21	3.03	3.20	0.07
Ribs Whole	5.15	5.37	5.27	5.71	5.52	5.48	0.03
Ribs Trimmed	3.99	4.11	4.16	4.61	4.66	4.52	0.03
Rear Leg	12.75^{bcd}	12.23^{d}	12.53^{cd}	13.41^{ab}	13.20^{abc}	13.56^{a}	0.04
Rear Leg Trot Off	12.07^{bc}	11.50^{c}	11.84^{c}	12.71^{ab}	12.55^{ab}	12.87^{a}	0.03
Rear Leg Shank Off	10.17^{bc}	9.61^{c}	9.98^{c}	11.00^{a}	10.84^{ab}	11.12^{a}	0.03
Rear Leg Trotter	0.69	0.73	0.69	0.69	0.65	0.69	0.004
Rear Leg Shank	1.90	1.89	1.86	1.71	1.71	1.75	0.02

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	Control	Deco.[e]	Monensin[f]	Control	Deco.[e]	Monensin[f]	MSE
Boneless Rear Leg	7.01[ab]	6.62[b]	6.92[ab]	7.29[ab]	7.65[a]	7.58[ab]	0.06
Back/ Loin	11.53[a]	11.15[ab]	11.47[a]	10.94[ab]	10.97[ab]	10.54[b]	0.05
Backstrip	5.58	5.25	5.36	5.56	5.99	5.69	0.04
Back-lip Off	3.62[a]	3.53[ab]	3.46[ab]	3.73[ab]	4.14[ab]	3.82[b]	0.03
Tenderloin	0.59	0.57	0.57	0.54	0.58	0.59	0.002
Semi.[h]	2.30	2.20	2.16	2.08	2.06	1.99	0.01
Lean yield[i]	20.57	19.19	19.48	20.36	20.76	20.68	3.42

[abcd] Least square means for a trait with different letters are different (P<0.05)
[e] Deco. = Decoquinate concentration 0.025 g/kg
[f] Monensin concentration 0.022 g/kg
[g] KPH = Kidney, Pelvic, and Heart Fat
[h] Semi. = *Semimembranosus*
[i] Lean yield = total boneless weight/ cold carcass weight * 100%

The means for the cut percentages by breed are in Table 3.31. There were some differences in various cut percentages. This indicates that the animals put on weight differently in different body parts. Differences in the live characteristics of the animals may have also caused some of the differences in cut percentages. For example, the differences in the live linear measurement heights between breeds could explain the differences in the trotter percentages since taller animals would be expected to have a greater trotter percentage of the carcass due to the increased bone mass.

Table 3. 31. Least squared means and mean squared error of carcass cuts as a percent of the cold carcass weight per breed

Trait	Harvest 1			Harvest 2			
	B-S[d]	S-S[e]	S. X M.[f]	B. X S.[d]	S. X S.[e]	S. X M.[f]	MSE
KPH[g]	3.52[a]	4.47[ab]	6.39[a]	3.64[b]	3.82[b]	3.58[b]	1.59
Foreleg	9.77	9.10	8.69	9.12	9.36	9.04	0.64
Foreleg Trot Off	9.21	8.54	8.25	8.59	8.80	8.60	0.59
Foreleg Shank Off	7.38[a]	6.60[b]	6.64[ab]	6.70[ab]	6.86[ab]	6.78[ab]	0.48
Foreleg Trotter	0.56[a]	0.55[ab]	0.44[b]	0.52[ab]	0.55[ab]	0.44[b]	0.01
Foreleg Shank	1.83	1.94	1.60	1.90	1.95	1.81	0.05
Boneless Foreleg	4.68	4.49	4.20	4.24	.44	4.37	0.35
Shoulder	8.41	8.89	8.54	8.73	9.50	9.59	1.70
Neck Off	5.82[b]	6.28[ab]	6.28[ab]	6.32[ab]	6.75[ab]	7.36[a]	1.34
Neck	2.59	2.61	2.26	2.42	2.75	2.22	0.22
Boneless Shoulder	2.89	2.83	2.90	3.05	2.83	3.34	0.42
Ribs Whole	4.76[c]	5.45[ab]	6.23[a]	5.13[bc]	5.57[ab]	5.91[a]	0.30
Ribs Trimmed	3.61[c]	4.34[b]	4.90[ab]	4.23[b]	4.54[ab]	4.91[a]	0.23
Rear Leg	13.01[b]	12.44[bc]	11.66[c]	13.95[a]	13.11[b]	13.12[b]	0.44

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	B-S[d]	S-S[e]	S. X M.[f]	B. X S.[d]	S. X S.[e]	S. X M.[f]	MSE
Rear Leg Trot Off	12.28[bc]	11.71[cd]	11.04[d]	13.26[a]	12.33[bc]	12.49[b]	0.40
Rear Leg Shank Off	10.31[bc]	9.77[c]	9.45[c]	11.56[a]	10.29[bc]	10.87[ab]	0.44
Rear Leg Trotter	0.73[a]	0.73[ab]	0.62[b]	0.68[ab]	0.78[a]	0.62[b]	0.009
Rear Leg Shank	1.98	1.95	1.58	1.70	2.04	1.62	0.12
Boneless Rear Leg	7.18[abc]	6.69[c]	6.44[c]	7.80[a]	6.90[bc]	7.61[ab]	0.53
Back/ Loin	11.62[a]	11.14[ab]	11.04[ab]	10.71[b]	10.50[b]	10.99[ab]	0.56
Backstrip	5.54	5.43	5.48	5.68	5.38	5.79	0.45
Back-lip Off	3.70	3.57	3.60	3.88	3.37	4.03	0.46
Tenderloin	0.61	0.57	0.54	0.55	0.52	0.63	0.02
Semi.[h]	2.32	2.14	2.21	2.12	1.98	2.07	0.15
Lean Yield[i]	19.07	18.14	17.68	19.52	18.05	19.99	3.59

[abc] Least square means for a trait with different letters are different (P<0.05)
[d] B-S = Boer-Spanish
[e] S-S = Savanna-Spanish
[f] S-M = Savanna-Myotonic
[g] KPH = Kidney, Pelvic, and Heart Fat
[h] Semi. = *Semimembranosus*
[i] Lean yield= total boneless lean / cold carcass weight * 100%

Table 3. 32. Least squared means and mean squared error of carcass cuts as a percent of the cold carcass weight by breed and treatment

Trait	Harvest 1									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
KPH[j]	3.36	4.37	5.69	3.58	3.96	6.68	3.63	5.06	7.22	1.77
Foreleg	9.65	9.05	8.78	10.07	9.48	8.46	9.60	8.75	8.93	0.69
Foreleg Trot Off	9.11	8.46	8.38	9.42	8.92	8.01	9.09	8.23	8.46	0.63
Foreleg Shank Off	7.27	6.52	6.68	7.51	6.86	6.52	7.35	6.40	6.80	0.51
Foreleg Trotter	0.54	0.58	0.41	0.64	0.56	0.45	0.51	0.52	0.47	0.01
Foreleg Shank	1.84	1.93	1.70	1.91	2.06	1.49	1.73	1.83	1.62	0.06
Boneless Foreleg	4.82	4.21	4.49	4.64	4.60	4.02	4.59	4.60	4.00	0.38
Shoulder	9.13[ab]	9.27[ab]	8.22[ab]	7.67[b]	8.70[ab]	8.83[ab]	8.42[ab]	8.79[ab]	8.58[ab]	1.60
Neck Off	6.23	6.78	5.76	5.23	5.97	6.42	6.10	6.18	6.62	1.36
Neck	2.90	2.49	2.46	2.45	2.71	2.19	2.41	2.61	1.97	0.21

(Table Cont'd)

Trait	Harvest 1									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
Boneless Shoulder	2.91	3.20	3.41	2.72	2.82	2.82	2.88	2.77	2.43	0.43
Ribs Whole	4.71[bc]	5.57[abc]	6.02[abc]	4.58[c]	5.56[abc]	6.22[a]	4.99[ac]	5.24[abc]	6.69[a]	0.31
Ribs Trimmed	3.63[b]	4.56[ab]	4.79[ab]	3.38[b]	4.21[ab]	4.95[ab]	3.82[b]	4.30[ab]	5.02[ab]	0.25
Rear Leg	13.45[abc]	12.76[abc]	11.69[c]	12.82[abc]	12.09[c]	11.61[c]	12.77[abc]	12.53[bc]	11.68[c]	0.40
Rear Leg Trot Off	12.76[ab]	12.07[bc]	11.10[c]	12.01[bc]	11.35[c]	10.97[c]	12.08[bc]	11.80[bc]	11.04[c]	0.35
Rear Leg Shank Off	10.83[abc]	10.29[abcd]	9.61[cd]	9.95[cd]	9.22[d]	9.17[d]	10.14[bcd]	9.90[cd]	9.70[cd]	0.35
Rear Leg Trotter	0.70	0.69	0.60	0.81	0.75	0.63	0.69	0.73	0.64	0.008
Rear Leg Shank	1.93	1.78	1.48	2.06	2.13	1.80	1.94	1.90	1.34	0.12
Boneless Rear Leg	7.62[ab]	7.05[ab]	6.74[ab]	6.87[ab]	6.34[b]	6.22[b]	7.05[ab]	6.75[ab]	6.28[ab]	0.49

(Table Cont'd)

Trait	Harvest 1									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
Back/ Loin	11.60	11.46	11.64	11.58	11.35	10.28	11.69	10.68	11.35	0.55
Backstrip	5.79	6.03	5.63	5.40	5.20	5.27	5.44	5.16	5.59	0.47
Back-lip Off	3.78	4.13	3.78	3.77	3.29	3.52	3.56	3.40	3.43	0.48
Tenderloin	0.62	0.61	0.62	0.64	0.56	0.55	0.58	0.55	0.55	0.02
Semi.[k]	2.45	2.17	2.35	2.31	2.06	2.17	2.19	2.19	2.01	0.17
Lean Yield[l]	19.91	18.90	18.83	18.63	17.61	17.02	18.66	18.07	16.70	3.94

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
KPH[j]	3.67	4.45	3.60	3.56	3.68	4.07	3.69	3.32	3.26	1.77
Foreleg	8.78	9.84	9.09	9.58	9.18	9.13	8.99	9.05	8.95	0.69
Foreleg Trot Off	8.23	9.26	8.64	9.07	8.71	8.72	8.48	8.44	8.48	0.63
Foreleg Shank Off	6.27	7.20	6.93	7.19	6.89	7.00	6.65	6.49	6.52	0.51
Foreleg Trotter	0.55	0.58	0.44	0.51	0.47	0.41	0.51	0.59	0.46	0.01
Foreleg Shank	1.96	2.06	1.71	1.89	1.82	1.71	1.84	1.96	1.96	0.06
Boneless Foreleg	3.94	4.54	4.66	4.22	4.55	4.25	4.55	4.22	4.22	0.38
Shoulder	9.48[ab]	8.45[ab]	9.63[ab]	7.96[ab]	9.10[ab]	9.34[ab]	8.74[ab]	10.95[a]	9.70[ab]	1.60
Neck Off	6.93	6.05	7.38	5.66	6.51	7.14	6.36	7.69	7.48	1.36
Neck	2.55	2.39	2.25	2.31	2.58	2.20	2.39	3.26	2.22	0.21

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
Boneless Shoulder	3.41	2.61	3.22	2.35	2.95	3.53	3.38	2.92	3.33	0.43
Ribs Whole	5.26[abc]	5.31[abc]	6.17[a]	5.09[bc]	5.92[abc]	6.07[ab]	5.04[bc]	5.46[abc]	5.60[abc]	0.31
Ribs Trimmed	4.14[ab]	4.49[ab]	4.99[ab]	4.25[ab]	4.77[ab]	5.14[a]	4.30[ab]	4.35[ab]	4.70[ab]	0.25
Rear Leg	13.81[ab]	12.48[bc]	13.28[abc]	14.21[a]	13.18[abc]	12.53[bc]	13.82[ab]	13.67[ab]	13.35[abc]	0.40
Rear Leg Trot Off	13.09[ab]	11.73[bc]	12.66[abc]	13.51[a]	12.44[abc]	11.93[bc]	13.18[ab]	12.82[ab]	12.70[abc]	0.35
Rear Leg Shank Off	11.55[a]	9.64[cd]	11.02[abc]	11.70[a]	10.18[abcd]	10.56[abcd]	11.42[ab]	11.05[abc]	10.94[abc]	0.35
Rear Leg Trotter	0.71	0.74	0.61	0.70	0.74	0.61	0.63	0.85	0.65	0.008
Rear Leg Shank	1.55	2.10	1.65	1.81	2.26	1.36	1.75	1.75	1.76	0.12
Boneless Rear Leg	7.72[ab]	6.55[ab]	7.28[ab]	7.82[ab]	6.65[ab]	8.45[a]	7.87[ab]	7.50[ab]	7.37[ab]	0.49

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
Back/ Loin	11.21	10.90	11.04	10.53	10.48	11.26	10.39	10.13	10.78	0.55
Backstrip	5.89	5.36	5.37	5.74	5.42	6.03	5.43	5.36	5.97	0.47
Back-lip Off	4.00	3.53	3.51	3.89	3.44	4.16	3.76	3.15	4.36	0.48
Tenderloin	0.54	0.55	0.58	0.54	0.52	0.61	0.56	0.49	0.68	0.02
Semi.[k]	2.25	1.94	2.04	2.15	1.97	1.90	1.95	2.03	2.19	0.17
Lean Yield[l]	19.60	17.77	19.25	18.83	18.11	21.00	20.13	18.28	19.96	3.94

[abcd] Least square means for a trait with different letters are different (P<0.05)
[e] Deco. = decoquinate concentration 0.025 g/kg
[f] Monen. = monensin concentration 0.022 g/kg
[g] B-S = Boer-Spanish
[h] S-S = Savanna-Spanish
[i] S-M = Savanna-Myotonic
[j] KPH= Kidney, Pelvic, and Heart Fat
[k] Semi. = *Semimembranosus*
[l] Lean Yield = total boneless weight/ cold carcass weight * 100%

3.3.6. Cooking Characteristics

The values for the cooking characteristics by treatment are in Table 3.33 and by breeds are in Table 3.34. Harvest 1 refers to the samples from the goats in each treatment that were slaughtered on day 45, and harvest 2 refers to the samples from the goats in each treatment that were sacrificed on day 60. Steaks 1 and 2 refer to the two steaks that were taken from the *M. Semimembranosus* of each goat carcass. The cook yield 1 and cook yield 2 refer to the yields after cooking of steak 1 and 2, respectively. Cook yield was calculated as (cooked steak weight/ raw steak weight) * 100%. Control and monensin diet treatments for harvest 1 resulted in greater cook yields of steaks than the diet treatments for harvest 2 ($P<0.05$). The control and monensin diet treatments had smaller raw steak 2 weights than the diet treatments from harvest 1 ($P<0.05$). The diet treatments for harvest 1 resulted in greater cook yield 2 and average cooking yield of steaks than the diet treatments for harvest 2 ($P<0.05$). The shear force values are lower than those previously reported for the *Semimembranosus* (Johnson et al., 1998) and slightly lower than those by Maynard (2015). Changes in the tenderness can be due to differences in the breeds or sex class when compared with the studies of Johnson et at. (1998) and Maynard (2015). There appears to be a relationship between the size of the *Semimembranosus* and the cook yields with larger *Semimembranosus* having a larger cook yield.

Table 3. 33. Least square means and mean square errors for the cooking characteristics of goat meat with feeding treatment and harvest time

Trait	Harvest 1			Harvest 2			
	Control	Deco.[d]	Monensin[e]	Control	Deco.[d]	Monensin[e]	MSE
Raw Semi., g	368.91	365.14	356.21	291.53	313.09	302.67	751.40
Raw Steak 1, g	118.08	121.55	103.65	102.60	113.64	102.57	78.22

(Table Cont'd)

Trait	Harvest 1			Harvest 2			
	Control	Deco.[d]	Monensin[e]	Control	Deco.[d]	Monensin[e]	MSE
Cooked Steak 1, g	92.56	91.73	80.15	73.23	83.60	74.32	58.33
Cook Yield 1, %	78.40[a]	75.48[ab]	77.32[a]	71.35[b]	73.35[ab]	72.46[ab]	2.25
Raw Steak 2, g	118.75[ab]	121.32[a]	115.78[ab]	88.91[c]	102.00[bc]	93.73	19.10
Cooked Steak 2, g	91.66[a]	94.28[a]	88.51[a]	62.56[b]	72.41[b]	70.95[b]	12.90
Cook Yield 2, %	77.15[a]	77.72[a]	76.45[a]	70.34[b]	70.99[b]	69.45[b]	1.40
Avg. Yield, %	77.78[a]	76.60[a]	76.89[a]	70.84[b]	72.17[b]	70.95[b]	0.75
Shear Force[f], g	5222	5056	5372	6449	5563	6505	957474

[abc] Least square means for a trait with different letters are different (P<0.05)
[d] Deco. = decoquinate concentration 0.025 g/kg
[e] Monensin concentration 0.022 g/kg
[f] Shear force = peak shear force value in grams

Table 3. 34. Least square means and mean square errors for the cooking characteristics of goat meat by breed

Trait	Harvest 1			Harvest 2			
	B-S[d]	S-S[e]	S-M[f]	B-S[d]	S-S[e]	S-M[f]	MSE
Raw Semi., g	370.53[ab]	312.53[bc]	482.41[a]	342.03[bc]	251.17[c]	311.04[bc]	5896
Raw Steak 1, g	117.09[ab]	101.36[bc]	142.62[a]	122.05[ab]	86.26[c]	108.41[abc]	491
Cook Steak 1, g	90.96[a]	76.65[bc]	115.48[a]	90.58[ab]	59.64[c]	79.11[bc]	370
Cook Yield 1, %	77.39[ab]	75.64[ab]	81.04[a]	73.52[abc]	68.16[c]	72.58[bc]	25
Raw Steak 2, g	120.13[b]	103.28[bc]	156.93[a]	107.30[b]	77.92[c]	98.07[bc]	579
Cook Steak 2, g	92.14[b]	75.89[bc]	129.19[a]	76.75[bc]	52.53[c]	69.73[bc]	425
Cook Yield 2, %	76.37[ab]	73.44[bc]	82.25[a]	71.01[bcd]	65.13[d]	69.48[cd]	29
Avg. Yield, %	76.88[ab]	74.54[bc]	81.64[a]	72.27[c]	66.65[d]	71.03[cd]	16
Shear Force[g], g	5202.81	5269.04	5119.85	6010.10	6359.29	6246.55	2613322

[abc] Least square means for a trait with different letters are different ($P<0.05$)
[d] B-S = Boer-Spanish
[e] S-S = Savanna-Spanish
[f] S-M = Savanna-Myotonic
[g] Shear force = peak shear force value in grams

3.4. Conclusions

While there were differences in some variables with diet treatment or harvest, most of the measurements in the experiment were not statistically different due to coccidiostat treatment. There were some consistent differences between breed or the interaction of breed and coccidiostat treatment. The differences in the breeds may have increased the error in the coccidiostat treatments. Increasing the duration of the experiment may produce more differences in results. Additionally, increasing the number of replications and using more goats of more similar weights or breeds could decrease the variation and provide clearer results. No definitive conclusion can be made about the effects of coccidiostat treatments on the carcass or meat characteristics of the goats from this experiment.

Table 3. 35. Least square means and mean square errors for the cooking characteristics of goat meat by breed and treatment

Trait	Harvest 1									
	Control: B-S[f]	Control: S-S[g]	Control: S-M[h]	Deco.[d]: B-S[f]	Deco.[d]: S-S[g]	Deco.[d]: S-M[h]	Monen.[e]: B-S[f]	Monen.[e]: S-S[g]	Monen.[e]: S-M[h]	MSE
Raw Semi., g	399.03[ab]	277.22[b]	461.92[ab]	342.78[ab]	327.12[ab]	531.69[a]	369.80[ab]	326.19[ab]	424.83[ab]	6319
Raw Steak 1, g	128.62[abc]	94.80[abc]	133.00[abc]	119.82[abc]	107.08[abc]	162.32[a]	102.82[abc]	100.89[abc]	122.46[abc]	467
Cook Steak 1, g	101.50[ab]	71.29[bc]	108.33[ab]	92.41[abc]	75.48[abc]	130.95[a]	78.96[abc]	82.10[abc]	98.30[abc]	344
Cook Yield 1, %	78.89[ab]	74.91[ab]	81.57[a]	68.65[ab]	76.74[ab]	70.81[ab]	76.54[ab]	81.06[a]	80.70[ab]	21.78
Raw Steak 2, g	124.22[ab]	96.56[ab]	146.70[ab]	116.95[ab]	106.60[ab]	171.93[a]	119.21[ab]	105.34[ab]	147.41[ab]	606.27
Cook Steak 2, g	96.23[abc]	70.28[bc]	120.74[ab]	89.22[abc]	80.78[abc]	143.35[a]	90.97[abc]	75.49[bc]	117.79[abc]	449.08
Cook Yield 2, %	77.25[ab]	72.65[ab]	82.27[ab]	75.99[ab]	75.61[ab]	83.04[a]	75.87[ab]	71.91[ab]	79.91[ab]	33.30
Avg. Yield, %	78.07[ab]	73.78[ab]	81.92[a]	76.37[ab]	73.21[ab]	82.04[a]	76.21[ab]	76.49[ab]	80.30[ab]	16.50
Shear Force[i], g	4926.23	6819.99	5354.75	4840.02	4766.57	4854.02	5842.18	4985.16	5181.70	2702557

(Table Cont'd)

Trait	Harvest 2									
	Control: B-S[g]	Control: S-S[h]	Control: S-M[i]	Deco.[e]: B-S[g]	Deco.[e]: S-S[h]	Deco.[e]: S-M[i]	Monen.[f]: B-S[g]	Monen.[f]: S-S[h]	Monen.[f]: S-M[i]	MSE
Raw Semi., g	371.66[ab]	225.19[b]	277.73[b]	316.16[ab]	289.21[ab]	327.23[ab]	338.28[ab]	239.11[b]	327.98[ab]	6319
Raw Steak 1, g	134.84[ab]	75.00[c]	98.04[abc]	124.89[abc]	98.95[abc]	113.23[abc]	106.43[abc]	84.83[bc]	113.81[abc]	467
Cooked Steak 1, g	102.70[ab]	49.43[c]	67.57[bc]	92.73[abc]	71.47[bc]	83.31[abc]	76.32[abc]	58.03[bc]	85.83[abc]	344
Cook Yield 1, %	76.02[ab]	65.21[b]	68.65[ab]	73.79[ab]	71.03[ab]	73.42[ab]	70.76[ab]	68.25[ab]	75.22[ab]	21.78
Raw Steak 2, g	116.56[ab]	66.53[b]	83.65[b]	113.47[ab]	90.12[b]	100.97[ab]	91.87[b]	77.11[b]	107.87[ab]	606.27
Cooked Steak 2, g	86.01[abc]	43.77[c]	57.89[bc]	80.45[abc]	62.83[bc]	73.28[bc]	63.79[bc]	50.99[c]	77.08[bc]	449.08
Cook Yield 2, %	73.71[ab]	64.05[b]	67.63[ab]	70.25[ab]	66.89[ab]	71.06[ab]	69.06[ab]	64.44[b]	70.02[ab]	33.30
Avg. Yield, %	74.87[ab]	64.63[b]	68.14[b]	72.02[ab]	68.96[b]	72.24[ab]	69.91[ab]	66.35[b]	72.62[ab]	16.50
Tenderness[f], g	5341.18	5812.43	7222.53	6292.14	7303.58	5219.32	6390.98	6528.43	6082.10	2702557

[abc] Least square means for a trait with different letters are different (P<0.05)
[d] Deco. = decoquinate concentration 0.025 g/kg
[e] Monen. = monensin concentration 0.022 g/kg
[f] B-S = Boer-Spanish
[g] S-S = Savannah-Spanish
[h] S-M = Savanna-Myotonic
[i] Shear Force= peak shear force value in grams

CHAPTER 4. MEAT GOAT PERFORMANCE, CARCASS TRAITS, AND MEAT CHARACTERISTICS OF KID GOATS SUPPLEMENTED WITH SUNN HEMP OR CONCENTRATES ON PASTURE

4.1. Introduction

In the early 2000s, numbers of meat goats increased faster than any other livestock commodity in the U.S. (Sande and Huston, 2007). There are many challenges to goat producers (Gillespie et al., 2013), with one of the largest cost inputs in any animal operation being feed (Solaiman, 2010). Recent U.S. Department of Agriculture (USDA) benchmark cost series indicate feed to be about 60 percent of the cost of broilers, turkeys, table eggs, and pigs. Feed is more than 70 percent of the benchmark cost of weight gain in High Plains cattle feeding operations (NRC, 2003). Utilizing forages to maintain and grow animals can help alleviate some of the costs associated with purchasing feed. One forage that can be used is sunn hemp (*Crotaliaria juncea).* Sunn hemp has nutritional levels in its leaves that are similar to those found in clovers, which make it an excellent feedstuff for animals (Warren et al., 2017). It is always questionable on the optimal time to supplement with concentrates to provide a producer with the most return on investments. The high nutritive value of sunn hemp may be a cheaper alternative to purchasing concentrate feeds for maintaining growth of kid meat goats during summer months when permanent pastures are less productive.

4.2. Materials and Methods

4.2.1. Animal Use

The Louisiana State University Agricultural Center Institutional Animal Care and Use Committee approved the research protocol (A2018-09) for care and use of live animals. Animals were housed at the Central Research Station in Baton Rouge, Louisiana.

4.2.2. Animal Procurement

All animals used on this project were acquired from the Louisiana State University Agricultural Center Central Research Station from kid goats born in the spring. The kids were Savanna (n=23) or Kiko-Savannah (n=14). Both wethers and does were used in this study. Prior to the study, all animals were ear tagged and vaccinated with 2 cc of *Clostridium perfringens* types C&D-tetanus toxoid (CD/T, Boehringer Ingelheim Animal Health USA Inc., Duluth, GA) subcutaneously under the supervision of a Louisiana State University (LSU) veterinarian. A second injection of CD/T was given 21 days later to all goats.

4.2.3. Experimental Treatments and Animal Allotment

Approximately 1.42 hectares of two 2.18-hectare permanent Bermudagrass pastures adjacent to two different sheds were disked in July and seeded with sunn hemp. Two other pastures on the other side of each shed served as control pastures. Sunn hemp and pasture or pasture with concentrate supplementation resulted in the two diet treatments associated with each shed. After weaning, Savannah (n=23) or Savannah x Kiko (n=14) kid goats, both does and wethers, were stratified by weight and breed to allocate the heaviest goats from each breed randomly to the pasture x replication treatment combinations (n=4) in descending weight order. The goats assigned to the sunn hemp and permanent pasture after weaning (Hemp) were then switched to the concentrate and pasture after day 50 and the goats assigned to the concentrate and pasture following weaning (Conc) were switched to the sunn hemp and pasture after day 50.

Each shed was divided by a fence so that goats from each side of the shed (pasture and sunn hemp or pasture and concentrate feed) had approximately 122.88 m^2 of covered shed with dirt floors and approximately 21,824 m^2 pasture or sunn hemp and pasture. Water was provided in large tubs in each half of each shed during the 100-day experiment.

4.2.4. Animal Nutrition

The guaranteed nutrient analysis of the Nutrena Country Feeds ® Goat 10% Medicated feed is in Table 4.1.

Table 4. 1. Guaranteed Analysis of Nutrena Country Feeds ® Goat 16% Medicated feed with decoquinate

Nutrient Composition	
Crude Protein (Min)……	16.00 %
Crude Fat (Min)..……	3.00 %
Crude Fiber (Max)……..…	16.00 %
Acid Detergent Fiber (ADF) (Max)……	17.00%
Calcium (Min)…….….	0.95%
Calcium (Max)…….	1.35 %
Phosphorus (Min)……	0.55 %
Salt (Min)…….……	1.25 %
Salt (Max)……	1.75 %
Sodium (Min)……	0.20%
Sodium (Max)……...	0.70%
Copper (Min)……..……	25 ppm
Copper (Max)……..	40 ppm
Selenium (Min)……..……..	0.60 ppm
Vitamin A (Min)…….……...	5,000 IU/lb

Rations needed for the trial were delivered to Central Research Station immediately prior to the study and ordered as needed in bags weighing approximately 22.68 kg stacked on pallets.

Random samples of each diet were taken from multiple bags and mixed thoroughly for nutrient assessment. Additionally, multiple samples of pasture forage were taken from each paddock housing goats for nutrient analysis. Pasture samples were taken from sunn hemp and permanent pasture. Pasture samples were taken using a 33 cm by 54 cm rectangle form randomly thrown throughout the pasture. All of the forage was taken from within the rectangle. Sun hemp samples were taken by grabbing leaves from throughout the plot. Samples were taken at the start, midway, and at the end of the project to monitor nutritional changes in the forages. The samples were dried in forced air ovens at 100°C to measure moisture content before analyses for other nutrients. The dry matter content was then ground before the samples were analyzed by the Louisiana State University Agricultural Chemistry laboratory for protein, crude fat, crude fiber, acid detergent fiber (ADF), ash and minerals, including boron, calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, sulphur, zinc (Table 4.2).

Table 4. 2. Analysis of feed and pasture samples

Nutrient Component Sample time	Pasture 1	Pasture 2	Pasture 3	Feed	Hemp 1	Hemp 2	Hemp 3
Dry Matter, %	35.57	26.79	30.60		19.90	22.67	20.06
Protein, %	10.90	8.85	10.80	16.10	24.15	24.70	27.20
Crude Fiber, %	29.69	24.82	30.85	11.65	17.38	25.05	18.79
ADF[a], %	36.84	33.89	42.01	17.52	24.03	34.78	25.19
Ash, %	8.49	8.54	9.44	9.83	9.86	10.60	10.57
Boron, ppm	36.35	25.20	<16.00	<16.00	17.40	36.95	37.10

(Table Cont'd)

Nutrient Component Sample time	Pasture 1	Pasture 2	Pasture 3	Feed	Hemp 1	Hemp 2	Hemp 3
Calcium, %	0.55	0.99	0.46	1.48	2.26	1.51	1.89
Iron, ppm	104.00	82.05	86.15	237.00	174.50	101.95	140.00
Magnesium, %	0.22	0.31	0.23	0.32	0.79	0.45	0.36
Manganese, ppm	50.10	77.75	94.05	149.00	95.25	80.65	92.90
Phosphorus, %	0.21	0.23	0.21	0.76	0.27	0.22	0.35
Potassium, %	1.83	1.16	1.48	0.92	1.01	1.30	1.15
Sodium, %	0.09	0.07	0.38	0.28	0.06	0.10	0.07
Sulphur, %	0.27	0.23	0.25	0.29	0.27	0.20	0.23
Zinc, ppm	39.65	33.70	38.05	123.50	54.15	41.85	54.50

[a] ADF = Acid detergent fiber

4.2.5 Live Animal Care

Goats in each pasture and concentrate treatment were fed twice daily, once in the morning around dawn and once in the evening around dusk, at 1.5% of the total goats' body weights per feeding. Wooden trough feeders along the length of the barn had one continuous opening for the goats to access. Twice a week, prior to feeding, the feed remaining in the troughs was recovered from each trough and weighed as refusal. Once a week, each animal was reweighed, and feed was adjusted to 1.5% of the adjusted total goat weights for that treatment per feeding. The equation used for feed allowance was total goat live weight * 0.015 = amount fed at each feeding. The same regime was followed after the goats were switched to the other feeding treatment after 50 days. Throughout the project, the animals were FAMACHA scored and checked for lice. Animals with a FAMACHA score of 3 or greater were dewormed with Prohibit® (levamisole hydrochloride, AgriLabs, St. Joseph, MO). Ultra Boss® (perethrin 5%

and piperonyl butoxide 5%, Merck, Kenilworth, NJ) was applied for the control of biting and sucking lice as needed.

4.2.6. Live Animal Measurements

On July 18th, goats were weighed for the beginning of the feeding trial starting weights. Linear measurements were recorded for the chine length, loin length, rump length, withers height, hip height, heart girth, barrel circumference, chest width, and chest depth while referencing the guidelines of McMillin et al. (2013). Live conformation scores were assigned by a trained researcher (McMillin and Pinkerton, 2008). Linear measurements were taken on days -2, 50, and 100. Weights were recorded on days -2, 5, 12, 19, 26, 33, 40, 47, 50, 54, 61, 68, 75, 82, 89, 96, and 100.

4.2.7. Harvesting procedure

Prior to holding animals without feed for slaughter, nine does were selected by the herd manager to keep as replacement does for the herd. Animals for harvest were removed and grouped into holding pens without feed twenty-four hours prior to slaughter. Water continued to be given *ad libitum*. The animals were transported roughly 6.5 kilometers from the Central Research Station to the LSU Meat Laboratory the morning of harvest. All goats were reweighed immediately upon exiting the trailer. Goats were rendered unconscious via captive bolt (model Cash Special captive bolt stunner 4100R) under the observation of Louisiana Department of Agriculture and Forestry state meat inspectors and exsanguinated. All hides were removed by pulling with an electric cable hoist (Model Number W154236, Yale Eaton, Forest City, Arkansas). After evisceration, carcasses were washed with water warmer than 35° C and weighed. Carcasses were chilled overnight at 3° C prior to carcass evaluation.

4.2.8. Carcass Measurements

Temperature and pH were measured at the time of hide removal and at 1 hour, 3 hours and 24 hours after stunning. Muscle pH and temperature were measured using a pH meter (Hach model H160, Loveland, CO, USA) with attached ISFET pH stainless steel microbe piercing probe with waterproof connector (Hach model PHW57-SS, Loveland, CO, USA) inserted into the center of the *M. Semimembranosus* as described by Kerth et al. (1999). Ten carcasses had digital temperature data loggers (TermoWorks model ThermaData Series II Temp Logger TC) inserted into the *M. Semimembranosus* to continuously record the rate of temperature decline in the carcasses.

After 24 hours of chilling, the circumferences of the rear legs at the widest dimension (center of the legs), of the rear legs at the tail, of the body at the heart girth (3rd and 4th ribs), and of the body at the chest (1st rib) and the length from the first rib to the aitch bone were measured using a tape measure. Carcass conformation, percent kidney, pelvic and heart fat (KPH) flank color and fat were evaluated by experienced personnel (McMillan and Pinkerton, 2008). Goats were ribbed using a handsaw between the 12th and 13th rib. Right and left rib eye areas were traced on an acetate pad (aquabee acetate pad, Bee Paper Company, United States). A digital planimeter (Topcon Model KP-82N, Japan) was used to trace loin eye areas to the closest square centimeters three different times and an average loin eye area was calculated.

After carcasses were ribbed between the 12th and 13th rib, the exposed *M. longissimus dorsi* was allowed to bloom 20 minutes. A Minolta spectrophotometer (model CM 508d, Konica Minolta, USA) with aperture opening 10.32 mm, illumination type D65, optical geometry 45°, and observer angle 2° was used to measure the surface L*, a* and b* color values of each loin

eye and the flank *M. Rectus abdominus*. The spectrophotometer averaged 3 readings at each of 3 locations to determine the final color reading.

Twenty-four hours post mortem, kidney pelvic and heart fat was removed prior to the carcasses being split into left and right sides along the backbone using a band saw (Butcher Boy model number SA20-F, Lasar MFG. Company, Inc. Los Angeles, CA). The right side of the carcasses were fabricated into primal cuts using the food service style (USDA, 2001), with an additional transverse cut between the 4^{th} and 5^{th} ribs. To obtain individual shank weights for this cut that is usually sold bone-in, carcasses were cut at the joint connecting the humerus bone to the radius and ulna, which was a deviation from the Fresh Goat IMPS food service style (USDA, 2001). Primal cuts were further separated into sub-primal cuts and retail cuts as pictured in Figure 4.1. Sub-primal cuts (foreleg without shank and trotters, shoulder without neck, back and loin, and the hind legs without shank and trotters) were manually deboned after fat removal with a knife to obtain boneless lean tissue. Weights were recorded for KPH, foreleg with shank and trotter, foreleg and shank with trotter removed, foreleg with shank and trotter removed, fore trotter, fore shank, boneless foreleg, shoulder with neck, shoulder without neck, neck, boneless shoulder, ribs with breast plate, ribs with breast plate removed, hind leg with shank and trotter, hind leg and shank with trotter removed, hind leg with shank and trotter removed, hind shank, hind trotter, boneless hind leg, back and loin with adhering abdominal tissue, and *M. Semimembranosus.* Cutting instructions similar to these have been reported on goats of different sizes (McMillin et al., 2013).

Figure 4. 1. Fabricated carcass side into cuts used in the study

The *M. semimembranosus* muscles were packaged in vacuum pouches (40.64 cm by 50.80 in 3-mil standard barrier nylon-polyethylene, Ultra Source; Kansas City, MO) with a slight vacuum (Turbovac, Howden Food Equipment B.V., The Netherlands). Packages were stored for a week at 3°C. Samples were removed from the packaging and weighed. The cap muscle was then trimmed from the *Semimembranosus* and reweighed, and then placed onto wire mesh in individual disposable pans (22 cm x 15 cm x 3 cm) to allow for drainage of drip during cooking. Samples were cooked in a conveyer oven (Lincoln model 1130-000-U-k1837, Fort Wayne, IN, USA) at a temperature of 204.4°C for 13 min to achieve an internal temperature of 75°C. The samples were cooled and reweighed to calculate cooking yield prior to storage. Cooking yield was calculated as cooked weight/raw weight * 100.

The samples were stored at 4°C overnight in clean baking pans (43.18 cm x 63.5 cm x 2.54 cm) covered with aluminum foil. Cylindrical cores (n=3) of 12.5 mm diameter (Schönfeldt et al., 1993) were removed parallel with muscle fibers from cooked cooled samples. Cores were

sheared perpendicular to the longitudinal orientation of the muscle fibers with a Warner-Bratzler shear attachment (Schönfeldt et al., 1993) using a 25 kg load cell and 240 mm per minute crosshead speed (Texture technologies Corp. model TA HD Plus, Scarsdale, New York). Peak force was measured in grams.

4.2.9. Data Analysis

The R-studio (Version 3.5.2, Rstudio, Boston, MA) aov function was used to analyze the data. Fixed effects included the supplement treatment, breed, and day. Means were determined as least square means analysis and differences were determined at $P<0.05$ utilizing the post hoc Tukey test. Pearson correlations were also calculated using the rcorr function. The correlations are in Appendix E.

4.3. Results and Discussion

4.3.1. Weight and Average Daily Gain

Least square means and the mean squared error for the weekly weights (kilograms) and the average daily gains (kilograms per day) for the treatments and the breeds are in Table 4.3. Figure 4.2 is a line graph of the weights with the standard error for each of the dates. Weights differed on different occasions throughout the experiment between the treatments. The ADG for the animals for the experiment were not different for the entire experiment ($p=0.06$). The average daily gains were in the range of 0.04 kg/day to 0.36 kg/day reported by Luginbuhl (2015). There were no differences between the interaction of treatments and breeds.

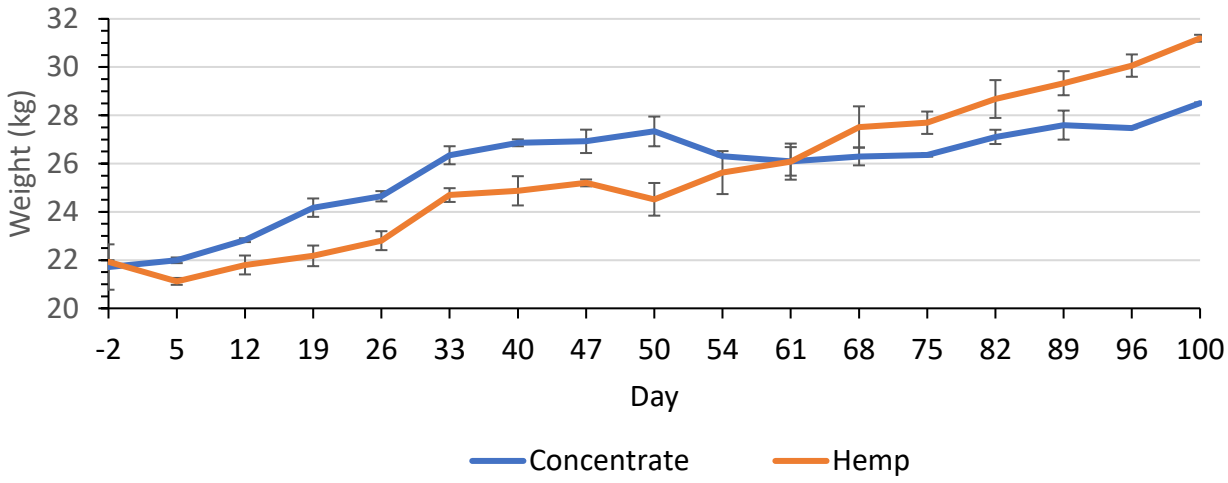

Figure 4. 2. Weekly weights (kg) for the animals by treatment.

Table 4. 3. Least square means and mean squared error for the weekly weights (kilograms) and average daily gains (kilograms per day) by treatment and by breed

Day	Conc.[c]	Hemp[d]	MSE	Savannah	Kiko[e]	MSE
-2	21.71	21.92	0.445	22.87[a]	20.23[b]	0.140
5	21.99[a]	21.11[b]	0.017	22.74[a]	19.84[b]	0.137
12	22.83	21.80	0.079	23.55[a]	20.53[b]	0.151
19	24.17[a]	22.18[b]	0.164	24.37	21.47	0.184
26	24.65[a]	22.81[b]	0.100	25.05[a]	21.83[b]	0.191
33	26.35[a]	24.70[b]	0.11	26.87[a]	20.24[b]	0.202
40	26.86[a]	24.87[b]	0.194	27.28[a]	23.86[b]	0.205
47	26.92[a]	25.20[b]	0.128	27.36[a]	24.19[b]	0.189
50	27.33	24.52	0.419	27.24	24.07	0.228
54	26.30	25.63	0.397	27.17	24.22	0.214
61	26.09	26.08	0.455	27.28	24.31	0.210

(Table Cont'd)

Day	Conc.[c]	Hemp[d]	MSE	Savannah	Kiko[e]	MSE
68	26.30	27.51	0.435	28.00	25.25	0.232
75	26.36	27.69	0.110	28.23	25.22	0.213
82	27.11	28.68	.0351	29.09	26.07	0.253
89	27.60	29.33	0.306	29.65	26.64	0.267
96	27.48[b]	30.06[a]	0.107	29.92	27.00	0.287
100	28.51[b]	31.20[a]	0.011	30.97	28.12	0.299
ADG[f]	0.068	0.093	0.0000419	0.08	0.08	0.0007

[ab] Least square means for a trait with different letters are different (P<0.05)
[c] Treatment: Concentrate then sunn hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Kiko = Kiko-Savannah
[f] ADG = (Day 100 weight – Day -2 weight)/100

4.3.2. Linear Measurement

Least Square means and mean squared error for linear measurements are in Table 4.4. The measurements were analyzed so that each treatment x day combination was compared to the other treatment x day combinations. The majority of the measurements did not change throughout the experiment. There were differences in heart girth, barrel circumference, and withers height (P<0.05). Maynard (2015) found large variations in linear measurements that could be a result of goats in different stances and moving while trying to measure. Additionally, differences due to variations in locating the specific anatomical parts used in measurements might add to the total variation of the measurements.

Table 4. 4. Least square means and mean square error of linear body measurements by treatment

Trait	Hemp[e]	Conc.[f]	MSE	Trait	Hemp[e]	Conc.[f]	MSE
Chine Length, cm				Loin Length, cm			
D -2	16.06	15.73		D -2	16.47	16.40	
D 50	18.12	17.46	0.5536	D 50	18.40	17.64	0.4477
D 100	18.43	17.35		D 100	18.58	18.85	
Rump Length, cm				Heart Girth, cm			
D -2	13.11	12.71		D -2	63.50^{cd}	62.12^{d}	
D 50	13.36	13.74	0.5951	D 50	67.65^{bc}	69.05^{b}	1.19
D 100	14.52	14.30		D 100	74.22^{a}	70.55^{ab}	
Barrel Circumference, cm				Hip Height, cm			
D -2	74.53^{c}	74.45^{c}		D -2	52.21	52.41	
D 50	79.14^{bc}	84.58^{abc}	8.27	D 50	57.52	58.77	3.94
D 100	97.72^{a}	88.65^{ab}		D 100	59.78	59.91	
Withers Height, cm				Chest Depth, cm			
D -2	53.24^{c}	52.78^{c}		D -2	22.23^{a}	22.03^{a}	
D 50	57.11^{b}	57.76^{ab}	0.4097	D 50	23.79^{b}	24.30^{b}	0.038
D 100	60.03^{a}	59.19^{ab}		D 100	25.92^{c}	25.23^{c}	
Chest Width, cm				Live Conformation[g], Subjective Score			
D -2	17.09	16.87		D -2	240	240	
D 50	16.81	17.56	0.1940	D 50	224	236	69.32
D 100	17.99	17.30		D 100	240	240	

[abcd] Least square means for a trait with different letters are different (P<0.05)
[e] Treatment: Sunn hemp access then concentrate after day 50

[f] Treatment: Concentrate then sunn hemp access after day 50
[g] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399 with 199 being the ideal market animal and 300 being the least desirable.

The least square means for the linear body measurements by breed are in Table 4.5. The differences are between days instead of breeds for all of the measurements except live conformation. This indicates that the animals were growing throughout the experiment which would be expected. The live conformation was different (P<0.05) with those of Savannah kid goats being greater than the Kiko-Savannah cross goats at day -2. However, that difference disappeared after that day. This would indicate that the goats became more uniform as the study continued.

Table 4. 5. Least square means and mean square error of linear body measurements by breed

Trait	Savannah	Kiko[f]	MSE	Trait	Savannah	Kiko[f]	MSE
Chine length, cm				Loin length, cm			
D -2	16.13^{bc}	15.48^{c}		D -2	16.58^{bc}	16.22^{c}	
D 50	17.93^{a}	17.53^{ab}	3.38	D 50	17.87^{ab}	18.22^{a}	2.526
D 100	18.21^{a}	17.25^{abc}		D 100	18.72^{a}	18.71^{a}	
Rump length, cm				Heart girth, cm			
D -2	63.96^{cd}	60.89^{d}		D -2	63.96^{cd}	60.89^{d}	
D 50	69.08^{b}	67.18^{bc}	20.09	D 50	69.08b	67.18^{bc}	20.09
D 100	73.37^{a}	70.61^{ab}		D 100	73.37^{a}	70.61^{ab}	
Barrel circumference, cm				Hip height, cm			
D -2	76.82^{cd}	70.68^{d}		D -2	52.49^{b}	52.03^{b}	
D 50	84.02^{b}	78.45^{bc}	44.10	D 50	58.98^{a}	56.62^{ab}	29.68
D100	92.88^{a}	85.58^{b}		D 100	59.98^{a}	59.45^{a}	

(Table Cont'd)

Trait	Savannah	Kiko[f]	MSE	Trait	Savannah	Kiko[f]	MSE
Wither height, cm				Chest Depth, cm			
D -2	53.42[b]	52.34[b]		D -2	22.48[de]	21.56[e]	
D 50	57.19[a]	57.80[a]	19.42	D 50	24.17[bc]	23.86[cd]	2.12
D 100	59.83[a]	59.13[a]		D 100	25.59[a]	25.52[ab]	
Chest width, cm				Live Conformation[g], Subjective score			
D -2	17.49[ab]	16.12[b]		D -2	247[c]	229[ab]	
D 50	17.58[ab]	16.59[ab]	2.28	D 50	235[abc]	224[a]	355
D 100	18.02[a]	16.66[ab]		D 100	243[bc]	236[abc]	

[abcde] Least square means for a trait with different letters are different (P<0.05)
[f] Kiko = Kiko-Savannah
[g] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399 with 199 being the ideal market animal and 300 being the least desirable.

The linear body measurement means are in Table 4.6. The majority of the differences were between days instead of the treatment and breed interaction. The one exception was in the barrel circumference with the Savannah group finished on concentrate having a greater barrel circumference than the Kiko-Savannah group finished on sunn hemp.

Table 4. 6. Least square means and mean square error of linear body measurements by breed and treatment

Trait	Conc.[f] Savannah	Conc.[f] Kiko[h]	Hemp[g] Savannah	Hemp [g] Kiko[h]	MSE
Chine length, cm					
D -2	15.91[b]	15.46[b]	16.34[ab]	15.49[b]	
D 50	17.84[ab]	16.92[ab]	18.01[ab]	18.33[ab]	3.40
D 100	17.69[ab]	16.74[ab]	18.69[a]	17.91[ab]	

(Table Cont'd)

Trait	Conc.[f] Savannah	Conc.[f] Kiko[h]	Hemp[g] Savannah	Hemp [g] Kiko[h]	MSE
Loin length, cm					
D -2	16.72[ab]	16.00[b]	16.45[b]	16.51[ab]	
D 50	17.80[ab]	17.37[ab]	17.93[ab]	19.35[a]	2.51
D 100	19.00[a]	18.61[ab]	18.46[ab]	18.84[ab]	
Rump length, cm					
D -2	13.42[ab]	11.75[b]	13.02[ab]	13.29[ab]	
D 50	14.11[ab]	13.24[ab]	13.14[ab]	13.80[ab]	1.857
D 100	14.52[a]	13.87[ab]	14.84[a]	14.48[a]	
Heart girth, cm					
D -2	63.48[cd]	60.29[d]	64.41[cd]	61.68[cd]	
D 50	70.73[ab]	66.71[bcd]	67.56[bcd]	67.82[abcd]	19.38
D 100	71.91[ab]	68.64[abc]	74.72[a]	73.24[ab]	
Barrel Circumference, cm					
D -2	78.00[de]	69.60[e]	75.73[de]	72.14[de]	
D 50	87.84[abc]	80.01[cde]	80.52[cd]	76.37[de]	41.30
D 100	92.73[ab]	82.90[bcd]	93.01[a]	89.15[abc]	
Hip height, cm					
D -2	53.50[ab]	50.93[b]	51.56[b]	53.51[ab]	
D 50	61.21[a]	55.09[ab]	56.94[ab]	58.67[ab]	29.28
D 100	60.75[a]	58.67[ab]	59.27[ab]	60.49[ab]	

(Table Cont'd)

Trait	Conc.[f] Savannah	Conc.[f] Kiko[h]	Hemp[g] Savannah	Hemp [g] Kiko[h]	MSE
Wither height, cm					
D -2	53.48[ab]	51.85[b]	53.36[ab]	53.00[ab]	
D 50	59.02[a]	55.94[ab]	55.52[ab]	60.28[a]	19.11
D 100	59.57[a]	58.58[ab]	60.07[a]	59.94[a]	
Chest Depth, cm					
D -2	22.55[cde]	21.34[e]	22.43[de]	21.85[de]	
D 50	24.55[abc]	23.98[abcd]	23.83[bcd]	23.72[bcde]	2.126
D100	25.46[ab]	24.90[ab]	25.70[ab]	26.35[a]	
Chest Width, cm					
D -2	17.55	15.93	17.44	16.38	
D 50	18.19	16.73	17.12	16.40	2.235
D 100	18.01	16.30	18.03	17.92	
Live conformation[i], Subjective score					
D -2	246	232	248	223	
D 50	245	225	226	222	350.069
D 100	244	235	242	238	

[abcde] Least square means for a trait with different letters are different ($P<0.05$)
[f] Treatment: Concentrate then sunn hemp access after day 50
[g] Treatment: Sunn hemp access then concentrate after day 50
[h] Kiko = Kiko-Savannah
[i] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399 with 199 being the ideal market animal and 300 being the least desirable.

4.3.3. FAMACHA Scores

The FAMACHA scores are in Table 4.7. There were no significant differences between treatment or breeds. There were no clear indication that the tested treatments had an effect on the FAMACHA scores and, by association, the parasite load of the animals.

Table 4. 7. Least square means and mean square error of FAMACHA scores by treatment and breed

Day	Conc[a]	Hemp[b]	MSE	Savanna	Kiko[c]	MSE
6	2.42	2.33	0.48	2.41	2.33	0.48
20	2.16	2.11	0.41	2.27	1.93	0.38
34	1.65	1.89	0.17	1.81	1.73	0.18
57	2.32	2.28	0.39	2.41	2.13	0.37
69	2.32	1.94	0.49	2.18	2.07	0.52
92	1.95	2.06	0.17	2.05	1.93	0.17

[a] Treatment: Concentrate then sunn hemp access after day 50
[b] Treatment: Sunn hemp access then concentrate after day 50
[c] Kiko = Kiko-Savannah

4.3.4. Carcass Measurements

Least squared means and mean squared error for the carcass measurements with treatments are in Table 4.8. Many of the measurements were not different ($P>0.05$). Dressing percentage and circumference at rib were different ($P<0.05$) with the goats in the treatment that received sunn hemp then were finished on concentrate having the greater values. The dressing percentages were similar to the average of 48% given by McMillin et al. (2013). The circumference values are lower in this study when compared to the goats on the coocidiostat study. This indicated that the animals for this experiment were not as heavily muscled as the goats used in the previous study.

Table 4. 8. Least squared means and mean squared error of carcass data by treatment

Trait	Conc.[c]	Hemp[d]	MSE	Trait	Conc.[c]	Hemp[d]	MSE
LW[e], kg	26.66	27.70	0.514	HCW[f], kg	12.83	14.07	0.100
CCW[g], kg	12.43	13.68	0.129	DP[h], %	48.13[a]	50.81[b]	0.003
Fat Score[i]	1.64	1.86	0.593	KPH[j], %	2.20	3.04	0.121
Carcass Conformation[k]	268	277	43.37	Circum. at Leg, cm[l]	46.68	48.66	0.318
Circum. at tail, cm[l]	46.65	48.06	0.172	Circum. at rib, cm[l]	62.79[a]	64.90[b]	0.159
Circum. at chest, cm[l]	60.74	62.25	0.484	Length 1st rib to crotch, cm	61.07	62.68	0.614
Body wall thickness, cm	1.04	1.37	0.096				

[ab] Least square means for traits with different letters are different (P<0.05)
[c] Treatment: Concentrate then sunn hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] LW= Live Weight
[f] HCW = Hot Carcass Weight
[g] CCW = Cold Carcass Weight
[h] DP = Dressing Percentage calculated as (HCW/LW) * 100
[i] Subjective fat covering over the ribs and shoulder 0 = none, 3 = completely covered
[j] KPH = Kidney, Pelvic, Heart Fat
[k] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399
[l] Circum. = circumference at the specified carcass location

The carcass measurements with breed are in Table 4.9 and with breed and treatment in Table 4.10. The only differences in the measurements were the dressing percentages, with the Kiko-Savannah goats having a greater dressing percentage than the Savannah kid goats. Additionally, the Kiko-Savannah goats finished on concentrates had a greater dressing percentage than goats in both Savannah x diet treatment groups.

Table 4. 9. Least squared means and mean squared error of carcass data by breed

Trait	Savannah	Kiko[c]	MSE	Trait	Savannah	Kiko[c]	MSE
LW[d], kg	28.12	26.24	26.62	HCW[e], kg	13.47	13.44	9.51
CCW[f], kg	13.07	13.05	9.26	DP[g], %	47.51[a]	50.91[b]	0.095
Fat Score[h]	1.71	1.78	0.60	KPH[i], %	2.81	2.46	1.26
Carcass Conformation[j]	208.57	229.29	879.40	Circum. at Leg, cm[l]	47.55	47.79	14.23
Circum. at tail, cm[l]	47.59	47.12	21.98	Circum. at rib, cm[l]	63.75	63.94	16.29
Circum. at chest, cm[l]	61.56	61.43	19.44	Length 1st rib to crotch, cm	62.07	61.69	14.41
Body wall thickness, cm	0.79	0.80	0.57				

[ab] Least square means for traits with different letters are different (P<0.05)
[c] Kiko = Kiko-Savannah
[d] LW= Live Weight
[e] HCW = Hot Carcass Weight
[f] CCW = Cold Carcass Weight
[g] DP = Dressing Percentage calculated as (HCW/LW) * 100
[h] Subjective fat covering over the ribs and shoulder 0 = none, 3 = completely covered
[i] KPH = Kidney, Pelvic, Heart Fat
[j] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399
[l]Circum. = circumference at the specified carcass location

Table 4. 10. Least squared means and mean squared error of carcass data by breed and treatment

Trait	Conc.[c] Savannah	Conc.[c] Kiko[e]	Hemp[d] Savannah	Hemp [d] Kiko[e]	MSE
Live weight, kg	29.18	24.78	27.33	28.20	26.67
Hot Carcass weight, kg	13.56	12.29	13.34	15.05	9.20
Cold Carcass weight, kg	13.23	11.84	12.94	14.66	8.88
Dressing percentage[f]	46.14[b]	49.29[ab]	48.54[b]	53.07[a]	0.074

(Table Cont'd)

Trait	Conc.[c] Savannah	Conc.[c] Kiko[e]	Hemp[d] Savannah	Hemp [d] Kiko[e]	MSE
Conformation conformation[g]	283	256	280	267	935.59
KPH[h], %	2.200	2.19	3.19	2.83	1.18
Fat Score[i]	1.83	1.50	1.63	2.17	0.58
Circumference at leg, cm	46.78	46.61	48.13	49.36	14.07
Circumference at tail, cm	47.63	45.91	47.56	48.73	22.68
Circumference at rib, cm	63.54	62.23	63.91	66.21	15.36
Circumference at chest, cm	61.98	59.82	61.02	63.88	18.57
Length 1st rib to crotch, cm	62.02	60.36	62.10	63.46	14.23
Body wall thickness, mm	7.07	6.83	8.42	9.44	4.89

[ab] Least square means for traits with different letters are different (P<0.05)
[c] Treatment: Concentrate then sunn hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Kiko = Kiko-Savannah
[f] DP = Dressing Percentage calculated as (HCW/LW) * 100
[g] KPH = Kidney, Pelvic, Heart Fat
[h] Subjective fat covering over the ribs and shoulder 0 = none, 3 = completely covered
[i] Subjective conformation score, Selection 1 = 100 to 199, Selection 2 = 200 to 299, Selection 3 = 300 to 399

The pH values with treatment and with breed are given in Table 4.11, with the interaction of treatment and breed in Table 4.12. The ultimate pH of the goat carcasses was greater than typically found in meat (pH 5.4 -5.7). However, it has been noted that goats' carcasses generally have a greater ultimate pH that can vary with breed due to their easily excitable nature (Webb et al., 2005).

Table 4. 11. Least squared means and mean squared error of muscle pH by breed and by treatment

Trait	Conc.[c]	Hemp[d]	MSE	Trait	Savannah	Kiko[e]	MSE
pH 1 hr	6.58	6.52	0.01231	pH 1 hr	6.60[a]	6.50[b]	0.01045
pH 3 hr	6.25	6.13	0.1065	pH 3 hr	6.28	6.10	0.1017
pH 24 hr	6.35	6.33	0.005764	pH 24 hr	6.34	6.34	0.0059

[ab] Least square means for traits with different letters are different (P<0.05)
[c] Treatment: Concentrate then sunn hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Kiko = Kiko-Savannah

Table 4. 12. Least square means and mean square error of muscle pH by breed and treatment.

Trait	Conc.[c] Savannah	Conc.[c] Kiko[e]	Hemp[d] Savannah	Hemp[d] Kiko[e]	MSE
pH 1 hr	6.64[a]	6.53[ab]	6.57[ab]	6.46[b]	0.00969
pH 3 hr	6.42	6.12	6.18	6.07	0.1010
pH 24 hr	6.36	6.34	6.33	6.33	0.0062

[ab] Least square means for traits with different letters are different (P<0.05)
[c] Treatment: Concentrate then sunn hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Kiko = Kiko-Savannah

The measurements for the flank color and the loin eye color and the subjective grade of the *M. Rectus abdominis* color are in table 4.13. There were no differences (P>0.05) in the muscle color. Goat meat color has been reported to range from L* 45.26 – 48.79, a* 10.05 – 12.11, and b* 0.95 – 2.57 (Yalcitan et al., 2018). The values in the present study were similar to their findings. Color variations can be due to differences in breed (Yalcitan et al, 2018).

Table 4. 13. Least square means and mean square error of flank and loin eye muscle color (*M. Rectus abdominis and Longissimus dorsi*) by treatment

Trait	Conc.[c]	Hemp[d]	MSE	Trait	Conc.[c]	Hemp[d]	MSE
Flank Color[a]				Loin eye color[a]			
L*	44.66	44.93	0.0691	L*	27.58	28.53	0.2867
a*	11.12	11.38	1.7317	a*	10.22	11.24	0.1182
b*	5.17	5.38	1.6945	b*	7.665	8.078	0.0298
Flank Color Score[b]							
	169	158	160.20				

[a] L* 0=black, 100 = white; a* -value =green, +value =red; b* -value=blue, +value =yellow
[b] 100 =light pink, 200 =reddish pink
[c] Treatment: Concentrate then Sunn Hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50

Table 4. 14. Least square means and mean square error of flank muscle color (*M. Rectus abdominis*) by breed

Trait	Savannah	Kiko[e]	MSE
Flank Color[c]			
L*	42.51[b]	47.09[a]	10.70
a*	12.19	10.31	6.71
b*	6.34[a]	4.21[b]	3.43
Flank Color Score[d]			
	172	155	145.60

[ab] Least square means for traits with different letters are different (P<0.05)
[c] L* 0=black, 100 = white; a* -value =green, +value =red; b* -value=blue, +value =yellow
[d] 100 =light pink, 200 =reddish pink
[e] Kiko = Kiko-Savannah

Table 4. 15. Least square means and mean square error of flank muscle color (*M. Rectus abdominis*) by breed and treatment

Trait	Conc.[c] Savannah	Conc[c] Kiko[e]	Hemp[d] Savannah	Hemp[d] Kiko	MSE
Flank color[f]					
L*	41.96[b]	46.89[a]	43.12[ab]	47.35[a]	11.27
a*	11.92	10.52	12.40	10.03	7.21
b*	5.78[ab]	4.71[ab]	6.76[a]	3.55[b]	3.39
Flank color score[g]	178.33	162.50	167.50	145.00	747.2

[ab] Least square means for traits with different letters are different (P<0.05)
[c] Treatment: Concentrate then Sunn Hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Kiko = Kiko-Savannah
[c] L* 0=black, 100 = white; a* -value =green, +value =red; b* -value=blue, +value =yellow
[d] 100 =light pink, 200 =reddish pink

The least square means and the means square error for the *M. longissimus dorsi* loin eye measurements (cm^2) are in Table 4.16. There were no differences in the loin eye areas with treatment. Similar loin eye areas have been reported in goats (Johnson et al., 1998). The goats in the current research were slaughtered at a similar age to the goats in that study.

Table 4. 16. Least square means and means square error of loin eye measurements (cm^2)

Treatment	Left loin eye	Right loin eye	Combined loin eyes	Average loin eye
Conc.[a]	9.02	9.51	18.53	9.26
Hemp[b]	9.58	9.74	19.31	9.66
MSE	0.0273	0.1962	0.2224	0.0556

[a] Treatment: Concentrate then sunn hemp access after day 50
[b] Treatment: Sunn hemp access then concentrate after day 50

The weights in grams for the portions of the right side of the goat carcasses and the cuts from each are in Table 4.17. The group that was given sunn hemp to start and finished on grain had greater weights in the foreleg with no shank, hindleg, hindleg without trotter, hindleg with shank removed, and boneless hindleg ($P<0.05$). The group that received concentrate first and was switched to the sunn hemp had greater boneless shoulder weight ($P<0.05$). The rest of the cuts did not exhibit any differences ($P>0.05$) with treatment.

Table 4. 17. Least Square Means and mean square error of carcass cuts (grams) with treatment

Trait	Conc.[c]	Hemp[d]	MSE	Trait	Conc.[c]	Hemp[d]	MSE
CCSW[e]	6355.07	7052.21	67873	KPH[f]	259.14	444.21	2437
Foreleg	1241.00	1333.93	473.88	Foreleg trotter off	1153.21	1241.64	479.44
Foreleg shank off	863.00[a]	944.37[b]	49.13	Foretrotter	88.43	92.29	34.98
Foreshank	290.21	297.57	663.37	Boneless Foreleg	573.00	618.57	1708.74
Shoulder	1130.93	1231.93	10980	Shoulder Neck-off	738.64	825.64	12342
Neck	392.71	406.50	168.33	Boneless Shoulder	357.86[a]	316.21[b]	82.86
Ribs Whole	588.36	667.38	2660.5	Ribs Trimmed	468.36	538.86	2335
Hindleg	1865.86[a]	1978.12[b]	145.33	Hindleg Trotter off	1756.50[a]	1868.04[b]	103.33
Hindleg Shank off	1448.29[a]	1588.31[b]	576.00	Rear trotter	109.36	126.26	385.81

(Table Cont'd)

Trait	Conc.[c]	Hemp[d]	MSE	Trait	Conc.[c]	Hemp[d]	MSE
Rear Shank	308.50	284.36	382.70	Boneless hindleg	994.50[a]	1127.43[b]	742.27
Back/loin	1231.71	1402.64	4556	Backstrip	598.78[a]	701.79[b]	384
Backstrip lip-off	428.00	468.79	2946	Tenderloin	54.64	57.64	17.32
Semi.[g]	289.21	322.07	235.70	Total boneless side[h]	2578.79	2821.64	6572

[ab] Least square means for traits with different letter are different (P<0.05)
[c] Treatment: Concentrate then Sunn Hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Cold Carcass Side Weight
[f] Kidney pelvic heart fat, total
[g] Semi. = *M. Semimembranosus*
[h] Total boneless side = boneless foreleg + boneless shoulder + boneless hindleg + backstrip + tenderloin

Table 4. 18. Least Square Means and mean square error of carcass cuts (grams) with breed

Trait	Savannah	Kiko[c]	MSE	Trait	Savannah	Kiko[c]	MSE
CCSW[d]	6355.07	7052.21	2121837	KPH[e]	298.14[b]	444.21[a]	16056
Foreleg	1241.00	1333.92	85161	Foreleg trotter off	1153.21	12.41	73980
Foreleg shank off	863.00	944.36	42639	Foretrotter	88.43	92.29	466.7
Foreshank	290.21	297.57	5608	Boneless Foreleg	618.57	573.00	23565
Shoulder	1130.93	1231.93	81880	Shoulder Neck-off	738.64	825.64	49693
Neck	392.71	406.50	15191	Boneless Shoulder	357.86	316.21	13905

(Table Cont'd)

Trait	Savannah	Kiko[c]	MSE	Trait	Savannah	Kiko[c]	MSE
Ribs Whole	588.36	667.36	30845	Ribs Trimmed	468.38	538.86	19992
Hindleg	1865.86	1978.92	147319	Hindleg Trotter off	1756.50	1868.54	132769
Hindleg Shank off	1448.29	1588.31	102070	Rear trotter	109.36	127.77	2200
Rear Shank	308.50	285.23	4716	Boneless hindleg	994.50	1127.43	58280
Back/loin	1231.71	1399.23	117148	Backstrip	598.79	701.79	33244
Backstrip lip-off	428.00	468.79	24118	Tenderloin	54.64	57.64	200
Semi.[f]	289.21	322.07	4082	Total boneless side[g]	2578.79	2821.64	355772

[ab] Least square means for traits with different letter are different (P<0.05)
[c] Kiko = Kiko-Savannah
[d] Cold Carcass Side Weight
[e] Kidney pelvic heart fat, total
[f] Semi. = *M. Semimembranosus*
[g] Total boneless side = boneless foreleg + boneless shoulder + boneless hindleg + backstrip + tenderloin

Table 4. 19. Least Square Means and mean square error of carcass cuts (grams) with treatment and breed

Trait	Conc. [c] Savannah	Conc.[c] Kiko[e]	Hemp[d] Savannah	Hemp[d] Kiko[e]	MSE
CCSW[f]	6008.83	6610.25	6614.75	7641.50	2094284
KPH[g]	284.33[b]	423.63[ab]	308.50[ab]	471.67[a]	16981
Foreleg	1205.50	1231.50	1267.63	1470.50	83547
Foreleg trotter off	1118.33	1144.88	1179.38	1370.67	72330

(Table Cont'd)

Trait	Conc. [c] Savannah	Conc.[c] Kiko[e]	Hemp[d] Savannah	Hemp[d] Kiko[e]	MSE
Foreleg shank off	842.17	872.75	878.63	1039.83	42014
Foretrotter	87.83	86.63	88.88	99.83	480.5
Foreshank	276.17	272.38	300.75	331.17	5495
Boneless foreleg	555.33	576.63	586.25	674.50	24024
Shoulder	1068.17	1124.50	1178.00	1375.17	78004
Shoulder neck off	675.83	745.75	785.75	932.17	47143
Neck	393.00	379.13	392.50	443.00	15875
Boneless Shoulder	307.83	292.63	395.38	347.67	13536
Ribs whole	538.17	614.75	626.00	733.50	30399
Ribs Trimmed	428.17	504.38	498.50	584.83	20027
Hindleg	1784.00	1907.50	1927.25	2093.20	152457
Hindleg trotter off	1677.33	1800.625	1815.88	1977.20	137282
Hindleg shank off	1373.00	1528.88	1504.75	1683.40	105164
Rear trotter	106.83	135.13	111.25	116.00	2339
Rear shank	304.33	279.50	311.63	294.40	5088
Boneless rear leg	918.83	1050.88	1051.25	1229.50	56073
Back/loin	1130.0	1305.50	1308.00	1549.20	114666
Backstrip	617.50	667.75	58.75	747.17	34960
Backstrip lip off	404.67	428.38	445.50	522.67	24620
Tenderloin	56.17	54.38	53.50	62.00	207.70

(Table Cont'd)

Trait	Conc. [c] Savannah	Conc.[c] Kiko[e]	Hemp[d] Savannah	Hemp[d] Kiko[e]	MSE
Semi.[h]	260.33	315.75	310.88	330.50	4026
Total boneless side[i]	2455.67	2642.25	2671.13	3060.83	353758

[ab] Least square means for traits with different letter are different (P<0.05)
[c] Treatment: Concentrate then Sunn Hemp access after day 50
[d] Treatment: Sunn hemp access then concentrate after day 50
[e] Kiko = Kiko-Savannah
[f] Cold Carcass Side Weight
[g] Kidney pelvic heart fat, total
[h] Semi. = *M. Semimembranosus*
[i] Total boneless side = boneless foreleg + boneless shoulder + boneless hindleg + backstrip + tenderloin

The percentages of each cut as a part of the side of the carcass are in Table 4.20. There were no differences (P>0.05) in each cut as a percentage of the cold carcass side weight. Additionally, there were no differences (P>0.05) found between breeds.

Table 4. 20. Least square means and mean squared error of the carcass cuts as percentages of the cold carcass side weight with treatment

Trait	Conc.[a]	Hemp[b]	MSE	Trait	Conc.[a]	Hemp[b]	MSE
Foreleg	19.58	18.87	0.0018	Foreleg trotter-off	18.58	17.56	0.0021
Foreleg Shank-off	13.65	13.33	0.0028	Foretrotter	1.40	1.30	0.000033
Foreshank	4.54	4.23	0.0005	Boneless Foreleg	9.04	8.77	0.0028
Shoulder	17.82	17.48	0.0070	Shoulder Neck-off	11.71	11.74	0.0117
Neck	6.12	5.75	0.0013	Boneless Shoulder	5.56	4.47	0.0007

(Table Cont'd)

Trait	Conc.[a]	Hemp[b]	MSE	Trait	Conc.[a]	Hemp[b]	MSE
Ribs Whole	9.18	9.40	0.0018	Ribs Trimmed	7.32	7.57	0.0019
Hindleg	29.48	29.36	0.0085	Hindleg Trotter off	27.73	26.76	0.0073
Hindleg Shank off	22.84	22.74	0.0019	Rear trotter	1.74	1.85	0.0010
Rear shank	4.90	4.13	0.0027	Boneless Hindleg	15.73	15.94	0.0017
Back/loin	19.24	19.85	0.0061	Backstrip	9.91	9.51	0.0031
Backstip Lip-off	6.63	6.63	0.0051	Tenderloin	0.88	0.82	0.00002
Semi.[c]	4.61	4.63	0.00013	Lean yield[d]	40.72	39.90	0.009

[a] Treatment: Concentrate then sunn semp access after day 50
[b] Treatment: Sunn hemp access then concentrate after day 50
[c] Semi. = *Semimembranosus*
[d] Lean yield = total boneless side weight/ cold carcass side weight * 100

4.3.5. Cooking Characteristics

The least square means and mean square errors for the cooking characteristics of goat meat from the treatments are in Table 4.21. There were no differences (P>0.05) in the goat meat cooking characteristics. Cooking loss percentages of 34.47 – 36.84 have been reported for goat meat (Yalcitan et al., 2018). These numbers correspond with 63.16 – 65.53 cooking yields. The cooking yields were slightly greater in the present study, which could be due to differences in muscles used in the different studies. Shear force values of 5.8 kg – 8.2 kg have been reported for the *M. Semimembranosus* by Johnson et al. (1995). There were no differences (P>0.05) in the cooking characteristics due to breed.

Table 4. 21. Least square means and mean square error for the cooking characteristics of goat meat with treatment

Treatment	*Semimembranosus* Raw Weight, g	*Semimembranosus* Cooked Weight, g	Cooking Yield, %	Average Shear Force, g
Conc.[a]	226.89	149.36	65.91	6406.17
Hemp[b]	240.26	163.89	68.20	7292.13
MSE	454.7	205.7	0.00095	633681

[a] Treatment: Concentrate then sunn hemp access after day 50
[b] Treatment: Sunn hemp access then concentrate after day 50

4.4. Conclusion

While there were some differences in the results of the experiment, there were not sufficient differences to draw solid conclusions about which supplementation method would improve growth, carcass traits, or meat characteristics. More of the results indicated that feeding the goats sunn hemp then finishing on a concentrate diet would be more beneficial for increasing the carcass weight than the reverse dietary treatment because of the increased hind leg weight. Furthermore, more replications might cause more differences to emerge. More research should be done in this area to provide clearer answers for producers.

CHAPTER 5. EFFECTS OF NITRITE-EMBEDDED PACKAGING ON COLOR STABILITY AND SHELF LIFE OF GOAT MEAT

5.1. Introduction

One of the biggest influences on consumer preferences of goat meat is color (Kadim and Maghoub, 2012), with a lighter pink color being preferred to darker colors (Harrison et al., 2013). Meat color is dependent on the concentration and form of myoglobin, the status of the iron bound in the compound, and the pH of the muscle (Kadim and Maghoub, 2012 Oxymyoglobin forms in presence of greater than 15% oxygen while deoxymyoglobin results when there is absence of oxygen. Insufficient reducing capacity in the meat allows the pigments to be oxidized to metmyoglobin, which is a major contributor to discoloration of meat (Mancini and Hunt, 2005). Different meat color is characteristic of raw fresh meat packaged in air-permeable, moisture-impermeable (overwrap), vacuum, or modified atmosphere packaging (MAP) (McMillin, 2008). Metmyoglobin will form after a few days under the partial pressures of oxygen that occur in polyvinyl chloride film overwrapped packaging environments, causing the meat color to change from red to brown. Vacuum packaging results in deoxymyoglobin pigments, which cause meat to be purple instead of red.

A new packaging material has been developed with nitrite crystals embedded in the film surface (Claus and Du, 2013). The nitrite crystals convert the myoglobin to nitrosomyglobin, which is bright red in color (Roberts et al., 2017). These changes have been shown to stabilize the color of bison steaks and patties and frozen beef (Roberts et al., 2017; Claus and Du, 2013). Similar changes are expected in goat meat, hence the objective of this study was to compare color of goat meat in overwrap, vacuum, and nitrite-embedded film during retail display.

5.2. Materials and Methods

5.2.1. Meat Procurement

The *Longissimus dorsi* of 24 goats from Savannah and Kiko-Savannah doe and wether kid goats were randomly assigned to one of three treatments. The treatments were overwrapping of polyvinyl chloride film around a Styrofoam tray with an absorbent pad (8cm by 15 cm Dri-loc® AC-2, Sealed Air Cryovac, Duncan, SC) (OWP), vacuum package (5 cm x 20 cm 3-mil standard barrier nylon-polyethylene pouches) (VAC) (Ultra Source; Kansas City, MO), and vacuum package (20.5 cm x 20.6 cm Freshcase® + high barrier film with 145 mg/m^2 NO_2 (NO2) (Bemis; Neenah, Wisconsin).

5.2.2. Sample preparation

The boneless loins of the goats were identified and placed into vacuum pouches (40.64 cm by 50.80 3-mil standard barrier nylon-polyethylene vacuum pouches Ultra Source; Kansas City, MO) and stored in 1°C for seven days to represent travel time from processing to the store. The loins of each animal were then cut into 1.9 cm thick medallions. Then two medallions were randomly selected and assigned to a package type and either 0, 3, 6, 9, or 12 days of retail display.

All of the medallions were then put into the designated packaging with the goat identification, treatment and retail display day. After sealing, the packages were randomly placed in a four vertical shelf retail display case (Hussmann model IM-04-I8-S; Bridgeton, MO) with the display lights illuminated at 2017 lumens 24 hours a day. The lumens were measured by random placement sampling with a light meter (Extech Instruments; Nashua, NH). The color was measured on day 0 samples before samples were vacuum sealed in 5 cm x 20 cm 3-mil standard

barrier nylon-polyethylene vacuum pouches (Ultra Source; Kansas City, MO) and stored at -20°C until analysis.

5.2.3. Color Measurements

On each of the designated display days, surface L*, a*, and b* were measured on samples from each packaging treatment with a Minolta spectrophotometer (model CM 508d, Konica Minolta, USA) with aperture opening 10.32 mm, illumination type D65, optical geometry 45°, observer angle 2°. The spectrophotometer averaged three readings per location at three locations that were then averaged for a final color reading for the sample.

5.2.4. Lipid Oxidation

Frozen samples were defrosted at 4°C overnight. Lipid oxidation was determined by an aqueous acid extraction method using modified procedures of Bostoglou (1994) (Appendix B). Stock solutions of malondialdehyde (MDA) standard solutions were prepared by weighing desired amounts of 1,1,3,3-tetraethoxypropane (TEB) diluting with 0.1 N HCL. After immersion into boiling water for 5 min and cooling with ice water, a standard solution of MDA was made by the TEB solution diluting to volume with distilled water.

The standard solution of MDA was made by pipetting increasing volumes of the stock solution and diluting with dH_2O. The standard curve was determined by pipetting each dilution with 2-thiobarbituric acid (TBA) solution and placing in boiling water for 30 min. The blank was 300 μL of dH2O and 200 μL TBA.

Two grams of muscle sample were homogenized with 5% trichloroacetic acid (TCA) and 0.08% butylated hydroxytoluene (BHT) dissolved in hexane for 30 seconds. After centrifugation at 3000g for 10 min, the top (hexane) and second phases were removed and the third phase was passed through 0.2 micrometer filter. The aliquot was mixed with 200 μL of TBA and incubated

in boiling water for 30 min together with the standard solution. The blank was made by mixing 5% TCA and TBA. A 96-well plate and plate reader were used to measure the absorbance of each standard and sample solution at 532 nm (Eppendorf model PlateReader AF2200; Hauppauge, NY).

Recovery was determined by standard solution of 5% TCA and BHT after centrifugation. After discarding the upper layer (hexane), it was reacted with TBA in boiling water. The obtained absorbance value was inserted in the mathematical formula obtained from the standard curve after subtraction of the blank value from the sample value and multiplied by 5 to get the total MDA content.

5.2.5. Protein Oxidation

A modified procedure described by Vossen and De Smet (2015) was used to analyze protein oxidation (Appendix C). A two-gram sample was homogenized with 20 mM phosphate buffer (pH 6.5) containing 0.6 M NaCl. The proteins in four aliquots of 0.2 mL from each sample were precipitated by adding ice-cold 10% trichloroacetic acid (TCA) and placing in an ice bath for 15 minutes. The supernatant was discarded after centrifuging the aliquots at 2,000 g for 30 minutes. Ice-cold 10% TCA was added to the aliquots in an ice bath and held for 15 minutes before centrifuging at 2,000 g for 30 minutes and discarding the supernatant. Two aliquots were treated with 10 mM 2,4-dinitrophenylhydrzine (DNPH) solution and two aliquots with 2.0 M HCl for a blank. The aliquots were placed on a shaker for 1 hour in dark conditions and then held at 4°C overnight in dark conditions.

The following morning, ice-cold 20% TCA was added to all aliquots, which were vortexed, and placed on ice bath for 15 min. After centrifugation of the samples at 2,000 g for 20 minutes, the supernatant was discarded. Ethanol/ethyl acetate solution was added in the first

washing cycle before vortexing and centrifuging at 2,000 g for 20 minutes. After discarding the supernatant, ethanol/ethyl acetate solution was added for a second washing, vortexing, and centrifuging of the samples at 2,000 g for 20 minutes and repeated for a third washing. After discarding the supernatant, excess solvent was evaporated from the samples for 15 min under a laboratory exhaust hood. A solution of 6 M guanidine-HCl in 20 mM phosphate buffer (pH 6.5) was added to the samples for shaking 30 min in dark conditions to dissolve the pellet. After centrifuging at 9,500 g for 10 min, samples were pipetted into a 96-well plate and a plate reader used to measure the absorbance at 280 nm and 370 nm (Biotek ® model PowerWave XS; Winooski, VT). The amount of hydrolyzed protein was calculated as $C_{hydrazone}/C_{Protein}$ = A370/ 22000M-1Mcm-1 *(A280-A370*0.43)*10^6.

5.2.6. Data Analysis

The R-studio (Version 3.5.2, Rstudio, Boston, MA) aov function was used to analyze the data. Fixed effects included the treatment and day. Means were determined using by least square means analysis and differences were determined at $P<0.05$ utilizing the post hoc Tukey test.

5.3. Results and Discussion

5.3.1. Color

The L*, a*, and b* measurements for each treatment type are in Table 4.1. There were differences in the L*, a*, and b* values at the beginning of the experiment ($P<0.05$) immediately after packaging. The a* value was lowest ($P<0.05$) with the NO2 packaging when compared to the other two packaging treatments. However, by day 3, the nitrosomyoglobin pigment had started to form and the color changed to a brighter red color. However, the color change associated with the nitrite embedded film only occurred when the meat was in direct contact with the film as any meat portion not in contact with the film was a brown color. Also, it was

subjectively noted that the odor of the goat meat in OWP changed with display, developing a smell of milk around day 9 and becoming stronger on day 12. The surface of the overwrapped goat meat also became tackier to the touch, indicating that there might be some microorganism growth although this was not measured and no visible bacterial colonies were observed. The L* values from the present study were greater than those reported by Gregorie (2016). The a* values were comparable to those reported for overwrapping and vacuum packaging of goat meat (Gregorie, 2016). The a* value for the nitrite embedded film mimicked more closely the results of the modified atmospheric packaging reported by Gregorie (2016). The b* results reported by Gregorie (2016) were noticeably lower than the ones reported in the present study. Differences could be due to the some of the cuts being frozen and thawed prior to retail display conditions in the Gregorie (2016) study.

Table 5. 1. Least square means and mean squared error of the influence of treatment time on *M. Longissimus dorsi* color in different packaging types

Loin eye color[d]	OWP[e]	VAC[e]	NO2[e]	MSE
L*				
D0	45.68[a]	42.30[b]	43.33[ab]	4.370
D3	44.42	42.10	41.42	5.612
D6	42.49	43.57	41.33	3.821
D9	40.75	41.63	40.36	5.209
D12	39.41	41.63	41.30	5.227
a*				
D0	14.95[a]	13.49[a]	10.26[b]	3.420
D3	11.93[b]	12.87[b]	16.58[a]	3.139

(Table Cont'd)

Loin eye color[d]	OWP[e]	VAC[e]	NO2[e]	MSE
D6	10.26[b]	14.06[a]	16.13[a]	2.949
D9	12.39[b]	14.18[b]	18.03[a]	2.480
D12	14.40[ab]	13.51[b]	16.20[a]	2.993
b*				
D0	12.63[a]	8.41[b]	12.43[a]	1.907
D3	13.77[a]	8.41[b]	12.86[a]	1.355
D6	12.75[a]	9.23[b]	12.45[a]	1.371
D9	10.71[b]	8.42[c]	13.48[a]	1.926
D12	9.15[b]	8.41[b]	12.56[a]	1.403

[abc] Least square means for traits with different letters are different (P<0.05)
[d] L* 0=black, 100=white; a* -value=green, +value=red; b*-value=blue, +value=yellow
[e]OWP = overwrapped air-permeable moisture impermeable film, VP = vacuum pouch, NO2 = nitrite-embedded film

5.3.2. Lipid Oxidation

Lipid oxidation concentrations as amounts of malondialdehyde (nM/L) are in Table 5.2. There were no differences in the lipid oxidation from day 0 until day 9. TBA is not selective to MDA, which can result in overestimations and variability (Salih et al., 1987). There was increased lipid oxidation in goat meat in overwrap packaging when compared to the other two packaging treatments on day 12 (P<0.05).

Table 5. 2. Least square means and mean square error of lipid oxidation as malondialdehyde (nM/L)

Treatment	Day 0	Day 3	Day 6	Day 9	Day 12
OWP[e]	0.0512	0.2564	0.3055	0.4091	1.4022[a]
VAC[e]	0.0503	0.0606	0.1797	0.3567	0.5823[b]

(Table Cont'd)

Treatment	Day 0	Day 3	Day 6	Day 9	Day 12
NO2[e]	0.0464	0.1279	0.5613	0.0533	0.3803[b]
MSE	0.0000541	0.0295	0.3863	0.1882	0.4227

[ab] Least square means for traits with different letters are different (P<0.05)
[e]OWP = overwrapped air-permeable moisture impermeable film, VP = vacuum pouch, NO2 = nitrite-embedded film

5.3.3. Protein Oxidation

The protein oxidation results are in Table 5.3. There were no differences among the treatments for the two days that samples were tested (P>0.05). This was due in part to the large variation seen in the results. Some of the variation in the protein oxidation can be due to differences in the composition of the goat meat samples analyzed. The samples used were chosen to have greater protein content and less fat, which could have influenced the results. Gravador et al. (2014) reported significantly lower values in the carbonyl content of lamb samples that were aged four days, then held for zero, three, of six days, with values ranging from 1.34 to 1.77 nmol/mg of proteins utilizing a similar method. The differences in holding time and species may have led to the carbonyl content being greater than previously reported.

Table 5. 3. Least square means and mean square error of protein oxidation (nmol/mg of protein)

Treatment	Day 0	Day 12
OWP[a]	19.89	100.75
VAC[a]	21.87	32.25
NO2[a]	7.18	37.38
MSE	643.06	14343.49

[a]OWP = overwrapped air-permeable moisture impermeable film, VP = vacuum pouch, NO2 nitrite-embedded film

5.4. Conclusion

The nitrite-embedded film contributed positively to the desirable red color of the meat when the film was in direct contact with the entire portion of the meat. Additionally, the vacuum packaging with regular barrier materials or the nitrite-embedded film delayed lipid oxidation. The nitrite-embedded packaging had beneficial results for packaging of fresh goat meat for retail display and sale in a self-service meat case. Further studies should be done to analyze the characteristics of goat meat in different packaging after freezing and thawing, as might be done by consumers.

CHAPTER 6. SUMMARY AND CONCLUSIONS

All of the studies focused on different methods of meat goat production and the characteristics of goat meat for consumers. Many production and management decisions made by a producer may influence the final meat product. Selection of coccidiostats and feeding strategies are two examples of routine decisions that must be made. There was inconclusive data to determine the influence of coccidiostats on meat goat carcasses or meat characteristics. Further studies with increased length of time on the decoquinate and monensin treatments using a more genetically similar group of animals are recommended. The method of feeding animals is highly dependent on the aim of the producer. The differences observed with the feeding strategies of supplementing native pastures were most notable for the increased dressing percentage of the animals finished on concentrate after initially grazing on sunn hemp and native pasture. Further studies should be conducted to examine the effect of feeding goats only forages and finishing on grain or concentrated diets for varying lengths of time. This would allow advising producers on the time needed for supplementing with concentrates depending upon the expected time of marketing the kid meat goats.

The last study examined different packaging materials so consumers more accustomed to purchasing meat from a self-service refrigerated meat case would have access to goat meat. The nitrite-embedded film changed the meat color to a brighter red color that would be more similar to color of other livestock meat species by consumers and controlled the lipid oxidation similarly to vacuum packaging. These two advantages make the nitrite-embedded film a viable option for processors and retailers to use for fresh goat meat packaging and self-service retail display. The lack of ongoing research on meat goat production and goat meat products provide opportunities

for conducting additional experiments to increase the knowledge that is available to producers, processors, and retailers.

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APPENDIX A. ANALYSIS OF VOLATILE FATTY ACIDS IN RUMINAL FLUID

Based on preparation procedures described in Grigsby et al., 1992. J. Anim. Sci. 70:1941-1949, and temperature gradient program described in Bateman et al., 2002. Prof. Anim. Sci. 18:363-367. Used by Doescher (2010).

Reagents

1. 25% (wt/vol) metaphophoric acid (fluka #79615) acid solution containing 2 g/L of 2-ethyl butyric acid (216.5 µL 2-EB to 100 mL m-phos acid solution; Aldrich #10, 995-9).
2. VFA standard: Add the following volumes of acids to a 100-mL volumetric flask and fill volume with dH2O. Store in refrigerator when not in use.

MW	Acid	Volume (µL)	Conc (g/L)	Conc (m*M*)
60.06	Acetic	330	3.46	57.62
74.08	Propionic	400	3.97	53.59
88.10	Isobutyric	30	0.29	3.29
88.10	Butyric	160	1.53	17.37
102.13	Isovaleric	40	0.375	3.67
102.13	n-Valeric	50	0.471	4.61

Sample and Standard Preparation

1) Centrifuge strained ruminal fluid at 30,000 x g for 20 min (this step may be skipped).
2) Mix 4 mL of rumen fluid supernatant with 1 mL of m-phosphoric acid solution containing 2-EB.
3) Allow to stand in ice bath for 30 min (this stepped may be skipped).
4) Centrifuge at 30,000 x g for 20 min.
5) Remove the supernatant for GC analysis.
6) To insure that standard is prepared in the same manner as the samples, treat the mixed sample from step A-2 above as a sample. Remember to correct the dilution factor from the m-phos solution when calculating the final VFA concentrations (4mL fluid mixed with 1 mL acid provide a correction factor of 1.25). For use on Shimadzu GC, samples should be in 2 mL autosampler vials. The optimal vials that we have used are ordered from Cole-Parmer. They are Target autosampler vials (#A98810-00). These are a screw cap vial so you also need caps, and the septa color is important. The autosampler recognizes white as the color of the septa (#A98801-23).

Temperature Gradient Program

7) The column temperature at the beginning of the program is 115°C and is held there for 0.1 min.
8) It is then increased at a rate of 10°C/min to 150°C and held there for 0.1 min.
9) It is then further increased at a rate of 11°C/min to 170°C and held there for 1 min.
10) The injector of the chromatograph is held at 250°C and the detector is held at 275°C.

11) Peak detection is by a flame ionization that uses a H2/ air flame.
12) Helium is used as the carrier gas with a splitless injection at a flow of 60 mL/min.

APPENDIX B. MODIFIED ANALYSIS OF LIPID OXIDATION

Modified procedures were based on those in Bostoglou (1994).

Reagent

1) 5% trichloroacetic acid (TCA)
2) Butylated hydroxytoluene (BHT)
3) 2-thiobarbituric acid (TBA)
4) 1,1,3,3-tetraethoxypropane (TEP, the MDA precursor)
5) HCL or standard MDA solution
6) Glacical acetic acid
7) Hexane

Preparation of MDA standard solution by using TEP for Standard Curve.

1. Weigh 73.2 mg of TEB in screw-cap tube and diluted with 10ml of 0.1 N HCL.
2. Immerse into boiled water for 5 min and cooled with ice water.
3. Transfer 239 μg/ mL standard solution of MDA into 100 mL volumetric flask and diluted to the volume with distilled water to get 2.39 μg/ mL equal to 0.03 μM / mL. Mark it as the stock standard solution.
4. The standard solution of MDA will be made as follows.
   a) Pipette 100, 300, 500, 700, 900 μL of the stock solution into a 1 mL Eppendorf tube and titrate with dH2O to 1 mL, to make 300, 900, 1500, 2100, 2700 nM/L.
5. Building standard curve.
   a) 300 μL of each standard solution will be reacted with 200 μL of 0.03 M TBA solution in the boiling water for 30 min. The blank is 300 μL of dH2O and 200 μL TBA.
6. Sample Processing.
   a) Weigh 2 grams of meat sample.
   b) Homogenize with 8 mL 5% TCA and 5 mL 0.08 BHT (solved in hexane) for 30 seconds.
   c) Centrifuge at 3000g for 10 min.
   d) There will four phases; remove the top (hexane) and second phase.
   e) Pass the third phase through 0.2 micrometer filter with a 3 mL syringe.
   f) Pipette 300 μL of the aliquot, mix with 200 μL of TBA and incubate in boiling water for 30 min together with the standard solution. Make blank against sample by mixing 300 μL 5% TCA and 200 μL TBA.
   g) Pipette 100 μL of each into a 96-well plate and use the plate reader to measure the absorbance at 532 nm.
7. Recovery Rate
   a) 1. Treat the standard solution as the sample, for every 1 mL of each standard solution, add 4 mL 5% TCA and 3 mL BHT.
   b) Centrifuge and discard the upper layer (hexane), about 3 mL.
   c) React with TBA in the boiling water.
8. Calculation for recovery rate.
   a) The tested absorbance value will be inserted in the formula based on the standard curve, after substrate the blank against the sample, the concentration of MDA in 5 mL is produced, and further multiply 5 to get the total MDA content. The estimated value is

compared to the true value (corresponding standard solution).

APPENDIX C. MODIFIED ANALYSIS OF CARBONYL CONTENT

Modified from procedures originally described in Levine et al. (1994) as cited in Vossen and De Smet (2015).

Reagents and materials:

Chemicals

(1) Phosphate buffer
(2) Trichloroacetic acid (TCA)
(3) DNPH (2,4-dinitrophenylhydrzine)
  1) CAS No. 119-26-6 (Sigma, D199303-25G, 100G, or 500G)
  2) MW: 198.14
(4) Ethanol
(5) Ethyl acetate
(6) Guanidine-HCl
  1) CAS No. 50-01-1 (Sigma, G3272-25G, 100G, 500G, 1KG, or 2KG)
  2) MW: 95.53

Reagents

(1) 20 mM phosphate buffer
(2) 20 mM phosphate buffer containing 0.6 M NaCl (pH 6.5)
(3) 10% TCA
(4) 20% TCA
(5) 2.0 M HCl
(6) 10 mM DNPH solution (dissolved in 2.0 M HCl)
(7) Ethanol/ethyl acetate solution (1:1 v/v)
(8) 6 M guanidine-HCl in 20 mM phosphate buffer (pH 6.5)

Procedures:

1. Homogenize a 2 g sample with 20 mL of the 20 mM phosphate buffer (pH 6.5) containing 0.6 M NaCl
2. Take 4 aliquots of 0.2 mL from each sample
3. Precipitate proteins in the aliquots by adding 1 mL of ice-cold 10% TCA
4. Stand for 15 min in an ice bath
5. Centrifuge at 2,000 g for 30 min
6. Discard the supernatant
7. Add 1 mL of ice-cold 10% TCA
8. Stand for 15 min in an ice bath
9. Centrifuge at 2,000 g for 30 min
10. Discard the supernatant
11. Treat two aliquots with 0.5 mL of 10 mM DNPH solution and two aliquots with 0.5 mL of 2.0 M HCl (blank)
12. Stand in a shaker for 1 hour (dark condition)
13. Hold at 4°C overnight (dark condition)
14. Add 0.5 mL of ice-cold 20% TCA, vortex, and place on ice bath for 15 min
15. Centrifuge at 2,000 g for 20 min

16. Discard the supernatant
17. Add 1 mL of ethanol/ethyl acetate solution (first washing)
18. Vortex and centrifuge at 2,000 g for 20 min
19. Add 1 mL of ethanol/ethyl acetate solution (second washing)
20. Vortex and centrifuge at 2,000 g for 20 min
21. Add 1 mL of ethanol/ethyl acetate solution (third washing)
22. Vortex and centrifuge at 2,000 g for 20 min
23. Evaporate excess solvent for 15 min under the hood
24. Add 1 mL of 6 M guanidine-HCl in 20 mM phosphate buffer (pH 6.5)
25. Stand in a shaker for 30 min (dark condition)
26. Centrifuge at 9,500 g for 10 min
27. Read the absorbance at 370 nm

➔ Calculation

$C_{hydrazone}/C_{Protein}$ = A370/ 22000M-1Mcm-1 *(A280-A370*0.43)*10^6

APPENDIX D. PEARSON CORRELATIONS FOR GROWTH AND MEAT PROPERTIES OF KID MEAT GOATS FED DIFFERENT COCCIDIOSTATS

Table D. 1. Pearson correlations of carcass measurements

	Cook Yield	Average Tenderness	Lean Yield	Shrink %	Average Rib-eye area	Carcass conformation
Cook Yield	1.0000					
P-value						
Average Tenderness	-0.3042	1.0000				
P-value	0.0089					
Lean Yield	0.1694	-0.0833	1.0000			
P-value	0.1520	0.4836				
Shrink %	0.1638	-0.1016	0.1695	1.0000		
P-value	0.1663	0.3924	0.1516			
Average Ribeye area	0.3717	-0.0650	0.1459	-0.3530	1.0000	
P-value	0.0013	0.5872	0.2215	0.0024		
Carcass Conformation	-0.1234	0.0205	-0.2056	0.0442	-0.2674	1.0000
P-value	0.2982	0.8630	0.0809	0.7104	0.0232	
pH at 1 hr	-0.3725	0.1308	0.1154	0.0086	-0.2244	-0.1727
P-value	0.0012	0.2700	0.3309	0.9426	0.0581	0.1439
pH at 3 hr	-0.5488	0.1879	0.2126	-0.0190	-0.2460	-0.1062
P-value	0.0000	0.1113	0.0710	0.8733	0.0372	0.3713
pH at 24 hr	-0.5740	0.2088	0.1830	-0.0511	-0.1673	-0.2129
P-value	0.0000	0.0763	0.1212	0.6679	0.1600	0.0705
Final Weight	0.5132	-0.2208	-0.2110	-0.2988	0.6944	-0.3666
P-value	0.0000	0.0605	0.0731	0.0102	0.0000	0.0014
ADG	0.3376	-0.0172	-0.2495	0.0080	0.1703	-0.1122
P-value	0.0035	0.8850	0.0333	0.9462	0.1527	0.3448

(Table Cont'd)

	Cook Yield	Average Tenderness	Lean Yield	Shrink %	Average Rib-eye area	Carcass conformation
Slaughter Weight	0.3665	-0.1533	-0.1695	-0.3705	0.6315	-0.3506
P-value	0.0014	0.1953	0.1516	0.0013	0.0000	0.0024
Hot Carcass Weight	0.3988	-0.1847	-0.0634	-0.3565	0.6703	-0.4012
P-value	0.0005	0.1177	0.5939	0.0020	0.0000	0.0004
Dressing Percent	0.2638	-0.1449	0.4613	-0.0366	0.3641	-0.3651
P-value	0.0241	0.2211	0.0000	0.7585	0.0017	0.0015
Cold Carcass Weight	0.4092	-0.1588	-0.0502	-0.3436	0.6705	-0.3969
P-value	0.0003	0.1796	0.6733	0.0029	0.0000	0.0005
KPH Score	0.1397	-0.0131	-0.1570	-0.3256	0.4680	-0.4745
P-value	0.2384	0.9123	0.1847	0.0049	0.0000	0.0000
Flank Score	0.3768	-0.1177	0.3471	0.0138	0.3935	-0.1697
P-value	0.0010	0.3212	0.0026	0.9080	0.0006	0.1512
Fat Score	0.3384	-0.1731	-0.1727	-0.2101	0.4203	-0.4438
P-value	0.0034	0.1431	0.1440	0.0745	0.0002	0.0001
Body wall Thickness	0.2621	-0.1481	-0.0665	-0.1612	0.2206	-0.4766
P-value	0.0251	0.2112	0.5763	0.1731	0.0626	0.0000
Circumference at Center Leg	0.4352	-0.1627	0.1190	-0.2609	0.7213	-0.4021
P-value	0.0001	0.1690	0.3158	0.0258	0.0000	0.0004
Circumference at Tail	0.3893	-0.0694	0.0483	-0.3135	0.6466	-0.4136
P-value	0.0007	0.5597	0.6851	0.0069	0.0000	0.0003
Circumference at Rib	0.4457	-0.2032	-0.0873	-0.3371	0.5919	-0.3210
P-value	0.0001	0.0847	0.4627	0.0035	0.0000	0.0056
Circumference at Chest	0.4705	-0.2430	0.0495	-0.3159	0.6863	-0.3092
P-value	0.0000	0.0383	0.6772	0.0065	0.0000	0.0078

(Table Cont'd)

	Cook Yield	Average Tenderness	Lean Yield	Shrink %	Average Rib-eye area	Carcass conformation
Length first rib to crotch	0.0756	0.0330	-0.0754	-0.4488	0.5288	-0.2112
P-value	0.5251	0.7815	0.5260	0.0001	0.0000	0.0729

	pH at 1 hr	ph at 3 hr	pH at 24 hr	Final weight	ADG	Slaughter Weight
pH at 1 hr	1.0000					
P-value						
pH at 3 hr	0.5041	1.0000				
P-value	0.0000					
pH at 24 hr	0.4421	0.7374	1.0000			
P-value	0.0001	0.0000				
Final Weight	-0.3369	-0.5231	-0.3572	1.0000		
P-value	0.0036	0.0000	0.0019			
ADG	-0.3551	-0.4406	-0.3282	0.5739	1.0000	
P-value	0.0021	0.0001	0.0046	0.0000		
Slaughter Weight	-0.2666	-0.3843	-0.2187	0.8758	0.4345	1.0000
P-value	0.0226	0.0008	0.0631	0.0000	0.0001	
Hot Carcass Weight	-0.2774	-0.3855	-0.2077	0.8581	0.4028	0.9737
P-value	0.0175	0.0008	0.0778	0.0000	0.0004	0.0000
Dressing Percent	-0.0862	-0.1019	0.0228	0.1823	0.0090	0.2055
P-value	0.4683	0.3911	0.8482	0.1227	0.9397	0.0811
Cold Carcass Weight	-0.2807	-0.3786	-0.2132	0.8551	0.3892	0.9660
P-value	0.0162	0.0010	0.0701	0.0000	0.0007	0.0000
KPH Score	0.0520	-0.1264	-0.0645	0.5960	0.4035	0.6289
P-value	0.6619	0.2865	0.5878	0.0000	0.0004	0.0000
Flank Score	-0.0859	-0.2304	-0.2291	0.3164	0.0727	0.2545
P-value	0.4701	0.0498	0.0512	0.0064	0.5411	0.0298

(Table Cont'd)

	pH at 1 hr	ph at 3 hr	pH at 24 hr	Final weight	ADG	Slaughter Weight
Fat Score	-0.0991	-0.4164	-0.2255	0.6784	0.3709	0.6548
P-value	0.4044	0.0002	0.0551	0.0000	0.0012	0.0000
Bodywall Thickness	-0.0418	-0.1378	0.0665	0.4740	0.3378	0.5257
P-value	0.7258	0.2450	0.5760	0.0000	0.0035	0.0000
Circumference at Center Leg	-0.2729	-0.3784	-0.1891	0.7715	0.2960	0.8747
P-value	0.0195	0.0010	0.1092	0.0000	0.0110	0.0000
Circumference at Tail	-0.1775	-0.3102	-0.1579	0.6989	0.2533	0.8084
P-value	0.1330	0.0076	0.1823	0.0000	0.0306	0.0000
Circumference at Rib	-0.3336	-0.4301	-0.2346	0.8169	0.3379	0.9331
P-value	0.0039	0.0001	0.0457	0.0000	0.0035	0.0000
Circumference at Chest	-0.3397	-0.3964	-0.2574	0.8131	0.3365	0.9056
P-value	0.0033	0.0005	0.0279	0.0000	0.0036	0.0000
Length first rib to crotch	-0.0362	-0.0579	0.0309	0.5457	0.1062	0.6965
P-value	0.7612	0.6264	0.7954	0.0000	0.3713	0.0000

	Hot Carcass Weight	Dressing Percent	Cold Carcass Weight	KPH Score	Flank Score	Fat Score
Hot Carcass Weight	1.0000					
P-value						
Dressing Percent	0.4175	1.0000				
P-value	0.0002					
Cold Carcass Weight	0.9886	0.4053	1.0000			
P-value	0.0000	0.0004				

(Table Cont'd)

	Hot Carcass Weight	Dressing Percent	Cold Carcass Weight	KPH Score	Flank Score	Fat Score
KPH Score	0.6402	0.2157	0.6191	1.0000		
P-value	0.0000	0.0668	0.0000			
Flank Score	0.3014	0.2733	0.3167	0.0722	1.0000	
P-value	0.0096	0.0193	0.0063	0.5439		
Fat Score	0.6974	0.3630	0.6770	0.6994	0.1758	1.0000
P-value	0.0000	0.0016	0.0000	0.0000	0.1369	
Bodywall Thickness	0.5808	0.4183	0.5542	0.5892	0.0608	0.6049
P-value	0.0000	0.0002	0.0000	0.0000	0.6094	0.0000
Circumference at Center Leg	0.9232	0.5069	0.9047	0.5023	0.3921	0.6099
P-value	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000
Circumference at Tail	0.8575	0.4823	0.8406	0.5133	0.3509	0.6502
P-value	0.0000	0.0000	0.0000	0.0000	0.0023	0.0000
Circumference at Rib	0.9371	0.3146	0.9289	0.4903	0.3068	0.5984
P-value	0.0000	0.0067	0.0000	0.0000	0.0083	0.0000
Circumference at Chest	0.9402	0.4414	0.9370	0.4764	0.3500	0.5860
P-value	0.0000	0.0001	0.0000	0.0000	0.0024	0.0000
Length first rib to crotch	0.6411	0.0038	0.6604	0.4300	0.1734	0.2521
P-value	0.0000	0.9748	0.0000	0.0001	0.1422	0.0314

(Table Cont'd)

	Bodywall Thickness	Circumference at center leg	Circumference at tail	Circumference at Rib
Bodywall Thickness	1.0000			
P-value				
Circumference at Center Leg	0.5053	1.0000		
P-value	0.0000			
Circumference at Tail	0.5400	0.8620	1.0000	
P-value	0.0000	0.0000		
Circumference at Rib	0.5220	0.8603	0.7666	1.0000
P-value	0.0000	0.0000	0.0000	
Circumference at Chest	0.4696	0.8867	0.7885	0.9390
P-value	0.0000	0.0000	0.0000	0.0000
Length first rib to crotch	0.2640	0.5589	0.5010	0.6434
P-value	0.0240	0.0000	0.0000	0.0000

	Circumference at chest	Length first rib to crotch
Circumference at Chest	1.0000	
P-value		
Length first rib to crotch	0.5789	1.0000
P-value	0.0000	

Table D. 2. Pearson correlations of carcass cut percentages

	KPH %	Foreleg %	Foreleg trotter off %	Foreleg Shank off %	Foretrotter %
KPH %	1.0000				
P-value					
Foreleg %	-0.4424	1.0000			
P-value	0.0001				

(Table Cont'd)

	KPH %	Foreleg %	Foreleg trotter off %	Foreleg Shank off %	Foretrotter %
Foreleg Trot off %	-0.4178	0.9921	1.0000		
P-value	0.0002	0.0000			
Foreleg Shank off %	-0.3485	0.9287	0.9543	1.0000	
P-value	0.0025	0.0000	0.0000		
Fore trotter %	-0.3236	0.4121	0.2952	0.1496	1.0000
P-value	0.0052	0.0003	0.0112	0.2064	
Fore Shank %	-0.3382	0.4775	0.4271	0.1377	0.5194
P-value	0.0034	0.0000	0.0002	0.2454	0.0000
Boneless Foreleg %	-0.3319	0.5258	0.5441	0.5759	0.0531
P-value	0.0041	0.0000	0.0000	0.0000	0.6556
Shoulder %	-0.2061	-0.4231	-0.4311	-0.4487	-0.1103
P-value	0.0802	0.0002	0.0001	0.0001	0.3530
Shoulder Neck off %	-0.1156	-0.5455	-0.5347	-0.5103	-0.2906
P-value	0.3300	0.0000	0.0000	0.0000	0.0126
Neck %	-0.2718	0.2100	0.1613	0.0528	0.4256
P-value	0.0200	0.0746	0.1728	0.6571	0.0002
Boneless Shoulder %	-0.2484	-0.1279	-0.0835	-0.0245	-0.3823
P-value	0.0341	0.2809	0.4826	0.8369	0.0008
Ribs whole %	0.3115	-0.3981	-0.3760	-0.3513	-0.2983
P-value	0.0073	0.0005	0.0010	0.0023	0.0104
Ribs Trimmed %	0.2716	-0.4032	-0.3873	-0.3900	-0.2581
P-value	0.0201	0.0004	0.0007	0.0006	0.0275
Hindleg %	-0.5402	0.2058	0.1779	0.0981	0.2663
P-value	0.0000	0.0806	0.1322	0.4089	0.0228
Hindleg Trotter off %	-0.5157	0.1738	0.1568	0.0932	0.1754
P-value	0.0000	0.1415	0.1853	0.4328	0.1377

(Table Cont'd)

	KPH %	Foreleg %	Foreleg trotter off %	Foreleg Shank off %	Foretrotter %
Hindleg Shank off %	-0.3784	0.0420	0.0352	0.0170	0.0553
P-value	0.0010	0.7245	0.7674	0.8863	0.6424
Hindleg Trotter %	-0.3122	0.3047	0.2114	0.0668	0.7823
P-value	0.0072	0.0088	0.0726	0.5744	0.0000
Hindleg shank %	-0.2440	0.2885	0.2665	0.1691	0.2620
P-value	0.0375	0.0133	0.0227	0.1527	0.0251
Boneless Hindleg %	-0.4341	0.0746	0.0876	0.0937	-0.0725
P-value	0.0001	0.5304	0.4614	0.4306	0.5420
Back/loin %	0.0044	-0.0397	-0.0178	0.0260	-0.1611
P-value	0.9706	0.7388	0.8814	0.8271	0.1732
Backstrip %	-0.3125	-0.0040	0.0314	0.0597	-0.2742
P-value	0.0071	0.9729	0.7919	0.6156	0.0189
Backstrip lip off %	-0.2991	0.0861	0.1132	0.1408	-0.1770
P-value	0.0101	0.4689	0.3401	0.2346	0.1342
Tenderloin %	-0.3049	0.2565	0.2892	0.2785	-0.1584
P-value	0.0087	0.0285	0.0131	0.0170	0.1806
Semimembranosus %	-0.2763	0.1790	0.1749	0.1784	0.0930
P-value	0.0180	0.1296	0.1389	0.1311	0.4338
Lean Yield	-0.4863	0.1939	0.2310	0.2712	-0.2122
P-value	0.0000	0.1002	0.0493	0.0203	0.0716

	Foreshank %	Boneless Foreleg %	Shoulder %	Shoulder Neck off %	Neck %
Fore Shank %	1.0000				
P-value					
Boneless Foreleg %	0.0657	1.0000			
P-value	0.5808				
Shoulder %	-0.0706	-0.2291	1.0000		
P-value	0.5530	0.0513			

(Table Cont'd)

	Foreshank %	Boneless Foreleg %	Shoulder %	Shoulder Neck off %	Neck %
Shoulder Neck off %	-0.2274	-0.2775	0.9307	1.0000	
P-value	0.0531	0.0175	0.0000		
Neck %	0.3753	0.0707	0.3999	0.0370	1.0000
P-value	0.0011	0.5524	0.0005	0.7558	
Boneless Shoulder %	-0.2044	0.1632	0.4185	0.5160	-0.1458
P-value	0.0828	0.1677	0.0002	0.0000	0.2184
Ribs whole %	-0.1858	-0.2586	0.3237	0.4117	-0.1494
P-value	0.1155	0.0272	0.0052	0.0003	0.2072
Ribs Trimmed %	-0.1057	-0.2374	0.2859	0.3804	-0.1736
P-value	0.3734	0.0431	0.0142	0.0009	0.1418
Hindleg %	0.2957	0.0551	0.1499	0.0908	0.1815
P-value	0.0111	0.6436	0.2057	0.4449	0.1243
Hindleg Trotter off %	0.2404	0.0629	0.1525	0.1131	0.1335
P-value	0.0405	0.5972	0.1978	0.3409	0.2603
Hindleg Shank off %	0.0667	-0.0036	0.1802	0.1879	0.0225
P-value	0.5751	0.9760	0.1271	0.1114	0.8501
Hindleg Trotter %	0.5009	-0.0421	0.0094	-0.1646	0.4332
P-value	0.0000	0.7236	0.9373	0.1641	0.0001
Hindleg shank %	0.3738	0.1521	-0.0942	-0.2004	0.2429
P-value	0.0011	0.1989	0.4278	0.0891	0.0384
Boneless Hindleg %	0.0098	0.0818	0.1839	0.2037	-0.0079
P-value	0.9345	0.4914	0.1193	0.0838	0.9471
Back/loin %	-0.1403	0.0143	-0.0670	-0.0592	-0.0313
P-value	0.2366	0.9043	0.5733	0.6189	0.7926
Backstrip %	-0.0724	0.2072	0.2112	0.2840	-0.1306
P-value	0.5427	0.0786	0.0729	0.0149	0.2708
Backstrip lip off %	-0.0505	0.1729	0.0474	0.1319	-0.1951
P-value	0.6711	0.1435	0.6905	0.2659	0.0982

(Table Cont'd)

	Foreshank %	Boneless Foreleg %	Shoulder %	Shoulder Neck off %	Neck %
Tenderloin %	0.1136	0.3093	-0.0105	0.0339	-0.1104
P-value	0.3384	0.0077	0.9296	0.7761	0.3524
Semimembranosus %	0.0355	0.3284	-0.0618	-0.0802	0.0330
P-value	0.7654	0.0046	0.6033	0.4999	0.7819
Lean Yield	-0.0527	0.4674	0.1612	0.2193	-0.1053
P-value	0.6577	0.0000	0.1731	0.0623	0.3751

	Boneless Shoulder %	Ribs Whole %	Ribs Trimmed %	Hindleg %	Hindleg trot off %
Boneless Shoulder %	1.0000				
P-value					
Ribs whole %	0.0291	1.0000			
P-value	0.8072				
Ribs Trimmed %	0.0450	0.8922	1.0000		
P-value	0.7052	0.0000			
Hindleg %	0.0187	-0.2894	-0.1837	1.0000	
P-value	0.8754	0.0130	0.1197		
Hindleg Trotter off %	0.0722	-0.2706	-0.1591	0.9927	1.0000
P-value	0.5439	0.0206	0.1788	0.0000	
Hindleg Shank off %	0.0982	-0.1366	-0.0213	0.8813	0.9070
P-value	0.4086	0.2490	0.8583	0.0000	0.0000
Hindleg Trotter %	-0.4269	-0.2140	-0.2429	0.2622	0.1443
P-value	0.0002	0.0690	0.0384	0.0250	0.2231
Hindleg shank %	-0.0752	-0.2780	-0.3030	0.1086	0.0639
P-value	0.5270	0.0172	0.0092	0.3606	0.5911
Boneless Hindleg %	0.3863	-0.2008	-0.1031	0.6233	0.6585
P-value	0.0007	0.0885	0.3855	0.0000	0.0000

(Table Cont'd)

	Boneless Shoulder %	Ribs Whole %	Ribs Trimmed %	Hindleg %	Hindleg trot off %
Back/loin %	0.0499	-0.1765	-0.2471	-0.2891	-0.2747
P-value	0.6752	0.1353	0.0351	0.0131	0.0187
Backstrip %	0.5602	-0.1641	-0.1165	0.1300	0.1734
P-value	0.0000	0.1653	0.3263	0.2729	0.1423
Backstrip lip off %	0.5914	-0.1929	-0.1096	0.0762	0.1110
P-value	0.0000	0.1020	0.3559	0.5215	0.3499
Tenderloin %	0.5309	-0.3353	-0.2869	-0.0059	0.0247
P-value	0.0000	0.0037	0.0139	0.9602	0.8357
Semimembranosus %	0.3797	-0.4108	-0.3943	0.1409	0.1419
P-value	0.0009	0.0003	0.0006	0.2345	0.2311
Lean Yield	0.7796	-0.2418	-0.1573	0.3082	0.3569
P-value	0.0000	0.0393	0.1839	0.0080	0.0019

	Hindleg Shank off %	Hind trotter %	Hind shank %	Boneless Hindleg %	Back/loin%
Hindleg Shank off %	1.0000				
P-value					
Hindleg Trotter %	-0.0213	1.0000			
P-value	0.8583				
Hindleg shank %	-0.3622	0.3683	1.0000		
P-value	0.0016	0.0013			
Boneless Hindleg %	0.7342	-0.1468	-0.2835	1.0000	
P-value	0.0000	0.2152	0.0151		
Back/loin %	-0.2332	-0.1623	-0.0514	-0.0434	1.0000
P-value	0.0470	0.1701	0.6657	0.7156	
Backstrip %	0.1987	-0.3175	-0.0901	0.3885	0.2532
P-value	0.0919	0.0062	0.4484	0.0007	0.0307
Backstrip lip off %	0.1171	-0.2659	-0.0305	0.3164	0.1035
P-value	0.3239	0.0230	0.7981	0.0064	0.3834

(Table Cont'd)

	Hindleg Shank off %	Hind trotter %	Hind shank %	Boneless Hindleg %	Back/loin%
Tenderloin %	0.0322	-0.2478	-0.0198	0.3028	0.2565
P-value	0.7869	0.0345	0.8680	0.0092	0.0285
Semimembranosus %	0.0792	0.0267	0.1280	0.3460	0.1429
P-value	0.5051	0.8227	0.2806	0.0027	0.2278
Lean Yield	0.3798	-0.3232	-0.1094	0.6986	0.0566
P-value	0.0009	0.0053	0.3568	0.0000	0.6344

	Backstrip %	Backstrip lip off %	Tenderloin %	Semimembranosus %	Lean Yield
Backstrip %	1.0000				
P-value					
Backstrip lip off %	0.7824	1.0000			
P-value	0.0000				
Tenderloin %	0.5665	0.6312	1.0000		
P-value	0.0000	0.0000			
Semimembranosus %	0.3929	0.4254	0.5385	1.0000	
P-value	0.0006	0.0002	0.0000		
Lean Yield	0.7181	0.7679	0.6817	0.5519	1.0000
P-value	0.0000	0.0000	0.0000	0.0000	

Table D. 3. Pearson correlation of linear measurements and weights

	Final weight	ADG	Chest Depth	Chest Width	Live conformation
Final Weight	1.0000				
P-value					
ADG	0.5739	1.0000			
P-value	0.0000				
Chest Depth	0.8113	0.2442	1.0000		
P-value	0.000	0.0373			
Chest Width	0.8430	0.4868	0.6845	1.000	
P-value	0.0000	0.0000	0.0000		

(Table Cont'd)

	Final weight	ADG	Chest Depth	Chest Width	Live conformation
Live conformation	-0.5266	-0.1480	-0.5116	-0.5614	1.000
P-value	0.0000	0.2114	0.0000	0.0000	
Chine Length	0.4683	-0.0003	0.5177	0.3004	-0.2765
P-value	0.0000	0.9983	0.0000	0.0098	0.0179
Loin length	0.5052	0.2030	0.4869	0.3021	-0.1238
P-value	0.0000	0.0850	0.0000	0.0094	0.2966
Rump Length	0.7065	0.3040	0.6597	0.5079	-0.3076
P-value	0.0000	0.0089	0.0000	0.0000	0.0081
Heart Girth	0.9310	0.3585	0.8755	0.8186	-0.5578
P-value	0.0000	0.0018	0.0000	0.0000	0.0000
Barrel Circumference	0.9211	0.6387	0.6385	0.7994	-0.4752
P-value	0.0000	0.0000	0.0000	0.0000	0.0000
Hip Height	0.6979	0.3641	0.6700	0.5158	-0.1671
P-value	0.0000	0.0015	0.0000	0.0000	0.1577
Wither Height	0.6874	0.1335	0.7453	0.5600	-0.2412
P-value	0.0000	0.2600	0.0000	0.0000	0.0398

	Chine length	loin length	Rump length	Heart Girth	Barrel Circumference
Chine Length	1.0000				
P-value					
Loin length	0.3588	1.0000			
P-value	0.0018				
Rump Length	0.4378	0.4493	1.0000		
P-value	0.0001	0.0001			
Heart Girth	0.5090	0.4468	0.6945	1.000	
P-value	0.0000	0.0001	0.0000		
Barrel Circumference	0.3737	0.3872	0.5925	0.8040	1.0000
P-value	0.0011	0.0007	0.0000	0.0000	

(Table Cont'd)

	Chine length	loin length	Rump length	Heart Girth	Barrel Circumference
Hip Height	0.4342	0.5623	0.6224	0.6429	0.5785
P-value	0.0001	0.0000	0.0000	0.0000	0.0000
Wither Height	0.4045	0.5371	0.6547	0.7197	0.4966
P-value	0.0004	0.0000	0.0000	0.0000	0.0000

	Hip Height	Wither Height
Hip Height	1.0000	
P-value		
Wither Height	0.8342	1.0000
P-value	0.0000	

APPENDIX E. PEARSON CORRELATIONS OF MEAT GOAT PERFORMANCE, CARCASS TRAITS, AND MEAT CHARACTERISTICS OF KID GOATS SUPPLEMENTED WITH SUNN HEMP OR CONCENTRATES ON PASTURE

Table E. 1. Pearson correlations of carcass measurements

	Weight Day 100	Slaughter Weight	Hot Carcass Weight	Chilled Carcass Weight
Weight Day 100	1.0000			
P-value				
Slaughter Weight	0.9833	1.0000		
P-value	0.0000			
Hot Carcass Weight	0.9750	0.9602	1.0000	
P-value	0.0000	0.0000		
Chilled Carcass Weight	0.9767	0.9612	0.9992	1.0000
P-value	0.0000	0.0000	0.0000	
Carcass Conformation	-0.7413	-0.7681	-0.7067	-0.7061
P-value	0.0000	0.0000	0.0000	0.0000
KPH Score	0.5953	0.5687	0.5827	0.5882
P-value	0.0011	0.0020	0.0014	0.0013
Flank Color Score	0.3920	0.4474	0.3733	0.3748
P-value	0.0391	0.0170	0.0504	0.0494
Fat Score	0.4563	0.4311	0.4864	0.4802
P-value	0.0147	0.0220	0.0087	0.0097
Circumference at Center leg	0.8911	0.8641	0.9312	0.9246
P-value	0.0000	0.0000	0.0000	0.0000
Circumference at Tail	0.8072	0.8037	0.8521	0.8540
P-value	0.0000	0.0000	0.0000	0.0000

(Table Cont'd)

	Weight Day 100	Slaughter Weight	Hot Carcass Weight	Chilled Carcass Weight
Circumference at Rib	0.9383	0.9149	0.9512	0.9555
P-value	0.0000	0.0000	0.0000	0.0000
Circumference at Chest	0.9445	0.9310	0.9653	0.9698
P-value	0.0000	0.0000	0.0000	0.0000
Length First Rib to Crotch	0.8517	0.8216	0.8321	0.8240
P-value	0.0000	0.0000	0.0000	0.0000
Bodywall thickness	0.6160	0.5441	0.6279	0.6203
P-value	0.0005	0.0028	0.0003	0.0004
Dressing Percent	0.5295	0.4436	0.6710	0.6644
P-value	0.0038	0.0181	0.0001	0.0001
Average Tenderness	-0.2093	-0.2410	-0.2593	-0.2682
P-value	0.2948	0.2260	0.1915	0.1762
Cook Loss	0.4850	0.4795	0.5332	0.5321
P-value	0.0120	0.0132	0.0050	0.0051
Cook Yield	0.5224	0.5092	0.5025	0.5003
P-value	0.0062	0.0079	0.0089	0.0092
Average Rib eye area	0.8610	0.8487	0.8752	0.8754
P-value	0.0000	0.0000	0.0000	0.0000
pH at 1 hr	0.1517	0.1970	0.0189	0.0220
P-value	0.4408	0.3149	0.9241	0.9114
pH at 3 hr	-0.1836	-0.1660	-0.2795	-0.2752
P-value	0.3497	0.3985	0.1498	0.1563
pH at 24 hr	-0.3968	-0.4052	-0.3798	-0.3801
P-value	0.0366	0.0324	0.0462	0.0460

(Table Cont'd)

	Carcass Conformation	KPH Score	Flank Color Score	Fat Score
Carcass Conformation	1.0000			
P-value				
KPH Score	-0.5208	1.0000		
P-value	0.0054			
Flank Color Score	-0.2884	0.1378	1.0000	
P-value	0.1366	0.4931		
Fat Score	-0.2313	0.1906	0.1509	1.0000
P-value	0.2362	0.3410	0.4434	
Circumference at Center leg	-0.7041	0.5001	0.3707	0.4414
P-value	0.0000	0.0079	0.0522	0.0187
Circumference at Tail	-0.7558	0.5919	0.3628	0.2992
P-value	0.0000	0.0011	0.0578	0.1219
Circumference at Rib	-0.6383	0.6030	0.3501	0.4718
P-value	0.0003	0.0009	0.0678	0.0112
Circumference at Chest	-0.6011	0.5514	0.3919	0.4715
P-value	0.0007	0.0029	0.0392	0.0113
Length First Rib to Crotch	-0.5143	0.4645	0.4787	0.5508
P-value	0.0051	0.0147	0.0100	0.0024
Bodywall thickness	-0.2683	0.3565	0.0930	0.1878
P-value	0.1675	0.0679	0.6378	0.3385
Dressing Percent	-0.2458	0.4122	0.0702	0.3624
P-value	0.2073	0.0326	0.7227	0.0580
Average Tenderness	0.0623	-0.3001	-0.2328	-0.1773
P-value	0.7577	0.1363	0.2425	0.3763
Cook Loss	-0.2669	0.3122	0.5853	0.2507
P-value	0.1875	0.1286	0.0017	0.2167

(Table Cont'd)

	Carcass Conformation	KPH Score	Flank Color Score	Fat Score
Cook Yield	-0.4079	0.3700	0.2179	0.2405
P-value	0.0386	0.0687	0.2848	0.2366
Average Rib eye area	-0.5848	0.4353	0.5512	0.3193
P-value	0.0011	0.0233	0.0024	0.0976
pH at 1 hr	-0.2185	0.0251	0.2281	-0.2322
P-value	0.2640	0.9011	0.2431	0.2344
pH at 3 hr	0.1280	-0.2803	-0.3267	-0.1163
P-value	0.5162	0.1567	0.0897	0.5556
pH at 24 hr	0.1633	-0.1293	-0.3317	-0.2783
P-value	0.4064	0.5204	0.0846	0.1515

	Circumference at center leg	Circumference at Tail	Circumference at Rib	Circumference at Chest
Circumference at Center leg	1.0000			
P-value				
Circumference at Tail	0.8559	1.0000		
P-value	0.0000			
Circumference at Rib	0.8760	0.8068	1.0000	
P-value	0.0000	0.0000		
Circumference at Chest	0.8616	0.8027	0.9662	1.0000
P-value	0.0000	0.0000	0.0000	
Length First Rib to Crotch	0.8143	0.6468	0.7834	0.7909
P-value	0.0000	0.0002	0.0000	0.0000
Bodywall thickness	0.6180	0.5446	0.5507	0.5722
P-value	0.0005	0.0027	0.0024	0.0015
Dressing Percent	0.7146	0.6276	0.6340	0.6332
P-value	0.0000	0.0003	0.0003	0.0003
Average Tenderness	-0.0323	-0.2013	-0.2481	-0.2980
P-value	0.8728	0.3139	0.2121	0.1311

(Table Cont'd)

	Circumference at center leg	Circumference at Tail	Circumference at Rib	Circumference at Chest
Cook Loss	0.5910	0.4699	0.5241	0.4915
P-value	0.0015	0.0154	0.0060	0.0108
Cook Yield	0.4040	0.4188	0.4409	0.4901
P-value	0.0407	0.0332	0.0242	0.0110
Average Rib eye area	0.8163	0.7803	0.8309	0.8847
P-value	0.0000	0.0000	0.0000	0.0000
pH at 1 hr	-0.0380	-0.0182	-0.0509	-0.0132
P-value	0.8478	0.9268	0.7972	0.9468
pH at 3 hr	-0.3427	-0.3431	-0.2144	-0.2173
P-value	0.0742	0.0739	0.2733	0.2666
pH at 24 hr	-0.3646	-0.1953	-0.3951	-0.4293
P-value	0.0565	0.3192	0.0374	0.0226

	Length First Rib to Crotch	Bodywall thickness	Dressing Percent	Average Tenderness
Length First Rib to Crotch	1.0000			
P-value				
Bodywall thickness	0.6103	1.0000		
P-value	0.0006			
Dressing Percent	0.5074	0.6024	1.0000	
P-value	0.0059	0.0007		
Average Tenderness	-0.0989	-0.0031	-0.2257	1.0000
P-value	0.6237	0.9879	0.2577	
Cook Loss	0.4507	0.2265	0.4529	-0.1551
P-value	0.0208	0.2658	0.0202	0.4493
Cook Yield	0.4902	0.3778	0.3080	-0.4039
P-value	0.0110	0.0570	0.1258	0.0407
Average Rib eye area	0.8044	0.5545	0.5834	-0.1872
P-value	0.0000	0.0022	0.0011	0.3498

(Table Cont'd)

	Length First Rib to Crotch	Bodywall thickness	Dressing Percent	Average Tenderness
pH at 1 hr	0.1535	0.1437	-0.4453	-0.1425
P-value	0.4354	0.4655	0.0176	0.4784
pH at 3 hr	-0.3515	-0.3435	-0.4548	0.1496
P-value	0.0667	0.0735	0.0150	0.4564
pH at 24 hr	-0.2994	-0.2306	-0.1787	0.0725
P-value	0.1217	0.2377	0.3629	0.7192

	Cook loss	Cook yield	Ribeye average area	pH at 1 hr	pH at 3 hr	pH at 24 hr
Cook Loss	1.0000					
P-value						
Cook Yield	-0.2767	1.0000				
P-value	0.1711					
Average Rib eye area	0.5039	0.4124	1.0000			
P-value	0.0087	0.0363				
pH at 1 hr	-0.1295	0.2461	0.0933	1.0000		
P-value	0.5284	0.2255	0.6368			
pH at 3 hr	-0.2533	-0.1486	-0.3190	-0.0478	1.0000	
P-value	0.2118	0.4689	0.0980	0.8090		
pH at 24 hr	-0.4386	-0.2520	-0.3063	0.1262	0.0920	1.0000
P-value	0.0250	0.2142	0.1130	0.5222	0.6413	

Table E. 2. Pearson correlations of carcass cuts percentages

	Slaughter Weight	Hot Carcass Weight	Chilled Carcass Weight	Lean Yield
Slaughter Weight	1.0000			
P-value				
Hot Carcass Weight	0.9602	1.0000		
P-value	0.0000			
Chilled Carcass Weight	0.9612	0.9992	1.0000	
P-value	0.0000	0.0000		

(Table Cont'd)

	Slaughter Weight	Hot Carcass Weight	Chilled Carcass Weight	Lean Yield
Lean Yield	0.0838	0.0343	0.0198	1.0000
P-value	0.6716	0.8625	0.9205	
KPH %	-0.0288	0.0461	0.0447	-0.5567
P-value	0.8842	0.8158	0.8215	0.0021
Foreleg %	0.1652	0.0388	0.0339	0.6102
P-value	0.4008	0.8448	0.8642	0.0006
Foreleg Trot off %	0.1673	0.0498	0.0451	0.5983
P-value	0.3949	0.8014	0.8198	0.0008
Foreleg Shank off %	0.1219	0.0263	0.0223	0.5933
P-value	0.5367	0.8945	0.9102	0.0009
Foretrotter %	0.0234	-0.1117	-0.1158	0.4363
P-value	0.9061	0.5713	0.5573	0.0203
Fore Shank %	0.1669	0.0734	0.0698	0.2461
P-value	0.3960	0.7106	0.7242	0.2067
Boneless Foreleg %	0.0613	-0.0314	-0.0169	0.4298
P-value	0.7567	0.8738	0.9321	0.0225
Shoulder %	-0.2555	-0.1776	-0.1739	-0.4186
P-value	0.1895	0.3660	0.3762	0.0266
Shoulder Neck off %	-0.3122	-0.2317	-0.2276	-0.4574
P-value	0.1058	0.2355	0.2442	0.0144
Neck %	0.1891	0.1587	0.1567	0.2097
P-value	0.3353	0.4199	0.4259	0.2841
Boneless Shoulder %	0.1000	0.0639	0.0603	0.3959
P-value	0.6128	0.7467	0.7606	0.0370
Ribs Whole %	0.2932	0.3198	0.3385	-0.2679
P-value	0.1300	0.0971	0.0781	0.1682
Ribs Trimmed %	0.3722	0.3773	0.3944	-0.2874
P-value	0.0512	0.0478	0.0378	0.1380

(Table Cont'd)

	Slaughter Weight	Hot Carcass Weight	Chilled Carcass Weight	Lean Yield
Hindleg %	-0.4310	-0.4821	-0.4857	0.3108
P-value	0.0248	0.0109	0.0102	0.1146
Hindleg Trot off %	-0.4232	-0.4563	-0.4593	0.2779
P-value	0.0278	0.0167	0.0159	0.1605
Hindleg Shank off %	-0.1974	-0.2547	-0.2487	0.3801
P-value	0.3237	0.1999	0.2109	0.0505
Rear trotter %	-0.2326	-0.2368	-0.2353	-0.3100
P-value	0.2431	0.2344	0.2373	0.1156
Rear Shank %	-0.4473	-0.4147	-0.4269	-0.1599
P-value	0.0193	0.0315	0.0264	0.4255
Boneless Hindleg %	-0.0067	0.0451	0.0455	0.6130
P-value	0.9731	0.8197	0.8180	0.0005
Back/loin %	0.4993	0.4712	0.4640	0.3799
P-value	0.0080	0.0131	0.0148	0.0506
Backstrip %	0.0022	0.0178	-0.0091	0.1884
P-value	0.9911	0.9284	0.9634	0.3369
Backstrip Lip off %	0.3757	0.2724	0.2639	0.3982
P-value	0.0488	0.1609	0.1748	0.0358
Tenderloin %	-0.1825	-0.2521	-0.2584	0.3423
P-value	0.3527	0.1956	0.1843	0.0746
Semimembranosus %	-0.3359	-0.3781	-0.3878	0.3010
P-value	0.0806	0.0473	0.0414	0.1195

	KPH %	Foreleg %	Foreleg Trotter off %	Foreleg Shank off %	Foretrotter %
KPH %	1.0000				
P-value					
Foreleg %	-0.4039	1.0000			
P-value	0.0331				

(Table Cont'd)

	KPH %	Foreleg %	Foreleg Trotter off %	Foreleg Shank off %	Foretrotter %
Foreleg Trot off %	-0.3833	0.9945	1.0000		
P-value	0.0441	0.0000			
Foreleg Shank off %	-0.3238	0.9172	0.9261	1.0000	
P-value	0.0928	0.0000	0.0000		
Foretrotter %	-0.4047	0.5941	0.5073	0.4332	1.0000
P-value	0.0327	0.0009	0.0059	0.0213	
Fore Shank %	-0.2849	0.5571	0.5516	0.1962	0.3613
P-value	0.1418	0.0021	0.0023	0.3170	0.0589
Boneless Foreleg %	-0.3836	0.5408	0.5186	0.4647	0.4807
P-value	0.0439	0.0030	0.0047	0.0127	0.0096
Shoulder %	-0.0088	-0.6280	-0.6576	-0.6329	-0.1050
P-value	0.9647	0.0003	0.0001	0.0003	0.5950
Shoulder Neck off %	0.1904	-0.6630	-0.6876	-0.6405	-0.1706
P-value	0.3318	0.0001	0.0001	0.0002	0.3853
Neck %	-0.3820	0.2674	0.2670	0.2157	0.1610
P-value	0.0449	0.1689	0.1696	0.2702	0.4131
Boneless Shoulder %	-0.6176	0.0852	0.0982	0.1395	-0.0435
P-value	0.0005	0.6663	0.6192	0.4791	0.8261
Ribs Whole %	-0.1053	-0.1919	-0.2092	-0.1838	0.0113
P-value	0.5939	0.3279	0.2854	0.3492	0.9544
Ribs Trimmed %	0.1008	-0.2096	-0.2309	-0.1924	0.0215
P-value	0.6097	0.2844	0.2371	0.3266	0.9135
Hindleg %	-0.4505	0.3549	0.3543	0.3852	0.2349
P-value	0.0184	0.0693	0.0698	0.0472	0.2383
Hindleg Trot off %	-0.4190	0.3099	0.3161	0.3553	0.1485
P-value	0.0296	0.1157	0.1082	0.0690	0.4597
Hindleg Shank off %	-0.3559	0.4352	0.4414	0.4988	0.1923
P-value	0.0685	0.0233	0.0212	0.0081	0.3366

(Table Cont'd)

	KPH %	Foreleg %	Foreleg Trotter off %	Foreleg Shank off %	Foretrotter %
Rear trotter %	-0.0430	-0.2312	-0.2531	-0.2890	0.0638
P-value	0.8314	0.2460	0.2027	0.1437	0.7520
Rear Shank %	-0.1721	-0.1720	-0.1719	-0.1940	-0.0542
P-value	0.3906	0.3910	0.3912	0.3323	0.7884
Boneless Hindleg %	-0.3290	0.2384	0.2512	0.3148	0.0432
P-value	0.0874	0.2218	0.1972	0.1027	0.8272
Back/loin %	-0.0977	0.0672	0.0755	0.0202	-0.0546
P-value	0.6279	0.7392	0.7083	0.9203	0.7869
Backstrip %	0.2823	0.0587	0.0474	0.0238	0.1053
P-value	0.1455	0.7667	0.8105	0.9045	0.5937
Backstrip Lip off %	-0.2038	0.3049	0.2760	0.1118	0.3745
P-value	0.2982	0.1146	0.1551	0.5711	0.0496
Tenderloin %	-0.3043	0.3646	0.3507	0.3046	0.3297
P-value	0.1154	0.0565	0.0673	0.1150	0.0866
Semimembranosus %	-0.1121	0.1677	0.1539	0.0312	0.2315
P-value	0.5701	0.3938	0.4343	0.8746	0.2359

	Foreshank %	Boneless Foreleg %	Shoulder %	Shoulder Neck off %	Neck %
Fore Shank %	1.0000				
P-value					
Boneless Foreleg %	0.3191	1.0000			
P-value	0.0979				
Shoulder %	-0.3122	-0.2554	1.0000		
P-value	0.1058	0.1896			
Shoulder Neck off %	-0.3758	-0.2415	0.8569	1.0000	
P-value	0.0487	0.2157	0.0000		
Neck %	0.2225	0.0544	-0.0434	-0.5522	1.0000
P-value	0.2552	0.7834	0.8263	0.0023	

(Table Cont'd)

	Foreshank %	Boneless Foreleg %	Shoulder %	Shoulder Neck off %	Neck %
Boneless Shoulder %	-0.0517	0.0586	0.1177	-0.0665	0.3186
P-value	0.7938	0.7670	0.5509	0.7368	0.0985
Ribs Whole %	-0.1322	0.0165	0.2346	0.2293	-0.0668
P-value	0.5024	0.9338	0.2295	0.2405	0.7357
Ribs Trimmed %	-0.1716	0.0190	0.1819	0.2094	-0.1130
P-value	0.3827	0.9236	0.3543	0.2848	0.5669
Hindleg %	0.0762	0.1126	-0.3151	-0.3199	0.1140
P-value	0.7056	0.5761	0.1094	0.1038	0.5713
Hindleg Trot off %	0.0428	0.1013	-0.3236	-0.3085	0.0780
P-value	0.8321	0.6151	0.0996	0.1175	0.6991
Hindleg Shank off %	0.0555	0.3421	-0.5254	-0.4512	0.0289
P-value	0.7833	0.0807	0.0049	0.0182	0.8862
Rear trotter %	-0.0218	-0.1385	0.3094	0.2299	0.0549
P-value	0.9139	0.4909	0.1164	0.2486	0.7858
Rear Shank %	-0.0233	-0.3353	0.2643	0.1805	0.0777
P-value	0.9081	0.0873	0.1828	0.3676	0.7003
Boneless Hindleg %	-0.0367	0.2606	-0.3248	-0.3557	0.1634
P-value	0.8530	0.1804	0.0917	0.0632	0.4062
Back/loin %	0.1543	0.1583	-0.3940	-0.4059	0.1508
P-value	0.4421	0.4302	0.0420	0.0356	0.4526
Backstrip %	0.0710	-0.5226	-0.1621	-0.0833	-0.0990
P-value	0.7196	0.0043	0.4100	0.6734	0.6161
Backstrip Lip off %	0.4731	0.1011	-0.3561	-0.2703	-0.0514
P-value	0.0110	0.6086	0.0629	0.1642	0.7952
Tenderloin %	0.2327	0.2306	-0.1857	-0.1237	-0.0606
P-value	0.2334	0.2378	0.3441	0.5306	0.7594
Semimembranosus %	0.3287	0.1788	-0.2816	-0.2243	-0.0189
P-value	0.0877	0.3628	0.1465	0.2512	0.9241

(Table Cont'd)

	Boneless Shoulder %	Ribs Whole %	Ribs Trimmed %	Hindleg %	Hindleg Trot off %
Boneless Shoulder %	1.0000				
P-value					
Ribs Whole %	-0.0376	1.0000			
P-value	0.8495				
Ribs Trimmed %	-0.1963	0.8552	1.0000		
P-value	0.3167	0.0000			
Hindleg %	0.2284	-0.3666	-0.4278	1.0000	
P-value	0.2518	0.0600	0.0260		
Hindleg Trot off %	0.2070	-0.3542	-0.4075	0.9921	1.0000
P-value	0.3002	0.0698	0.0349	0.0000	
Hindleg Shank off %	0.1366	-0.0504	-0.1075	0.7993	0.8109
P-value	0.4968	0.8027	0.5937	0.0000	0.0000
Rear trotter %	0.0247	-0.0625	-0.0951	0.3017	0.2724
P-value	0.9027	0.7568	0.6370	0.1262	0.1693
Rear Shank %	0.1369	-0.5011	-0.5117	0.5441	0.5421
P-value	0.4959	0.0078	0.0064	0.0033	0.0035
Boneless Hindleg %	0.2014	-0.0988	-0.1804	0.2428	0.2456
P-value	0.3042	0.6169	0.3583	0.2223	0.2168
Back/loin %	0.1554	-0.2208	-0.1596	-0.3277	-0.3100
P-value	0.4390	0.2683	0.4265	0.0952	0.1156
Backstrip %	-0.3482	-0.2403	-0.1210	-0.0188	-0.0353
P-value	0.0694	0.2181	0.5396	0.9258	0.8612
Backstrip Lip off %	-0.2202	-0.0598	-0.0014	-0.0771	-0.0972
P-value	0.2602	0.7624	0.9945	0.7024	0.6297
Tenderloin %	-0.1768	-0.1425	-0.0124	0.0785	0.0591
P-value	0.3680	0.4695	0.9501	0.6972	0.7698
Semimembranosus %	-0.2530	-0.3185	-0.3442	0.2470	0.2404
P-value	0.1940	0.0986	0.0729	0.2143	0.2271

(Table Cont'd)

	Hindleg Shank off %	Rear-trotter %	Rear Shank %	Boneless Hindleg %	Back/loin %
Hindleg Shank off %	1.0000				
P-value					
Rear trotter %	0.1486	1.0000			
P-value	0.4595				
Rear Shank %	-0.0376	0.4342	1.0000		
P-value	0.8524	0.0236			
Boneless Hindleg %	0.4482	-0.1243	-0.2445	1.0000	
P-value	0.0190	0.5368	0.2190		
Back/loin %	-0.2223	-0.4035	-0.2670	0.2769	1.0000
P-value	0.2650	0.0369	0.1782	0.1621	
Backstrip %	-0.1760	-0.1849	0.1306	-0.2136	0.0491
P-value	0.3799	0.3557	0.5160	0.2750	0.8079
Backstrip Lip off %	-0.0748	-0.1964	-0.1041	0.0505	0.5089
P-value	0.7109	0.3261	0.6052	0.7987	0.0067
Tenderloin %	-0.0232	-0.2429	0.0590	0.0085	0.1607
P-value	0.9086	0.2221	0.7699	0.9656	0.4233
Semimembranosus %	0.1341	-0.0224	0.1928	0.2172	0.2468
P-value	0.5048	0.9116	0.3354	0.2669	0.2146

	Backstrip %	Backstrip Lip off %	Tenderloin %	Semimembranosus %
Backstrip %	1.0000			
P-value				
Backstrip Lip off %	0.4829	1.0000		
P-value	0.0092			
Tenderloin %	0.2545	0.3792	1.0000	
P-value	0.1913	0.0466		
Semimembranosus %	0.2265	0.3656	0.3407	1.0000
P-value	0.2465	0.0557	0.0761	

Table E. 3. Pearson correlations of linear measurements

	Weight Day 100	Chest Depth	Chest Width	Live conformation	Chine Length
Weight Day 100	1.0000				
P-value					
Chest depth	0.8763	1.0000			
P-value	0.0000				
Chest Width	0.7948	0.7042	1.0000		
P-value	0.0000	0.0000			
Live Conformation	-0.4385	-0.3899	-0.5677	1.0000	
P-value	0.0196	0.0402	0.0016		
Chine Length	0.7284	0.7338	0.4718	-0.3110	1.0000
P-value	0.0000	0.0000	0.0113	0.1072	
Loin Length	0.6616	0.6639	0.5100	-0.4219	0.5577
P-value	0.0001	0.0001	0.0056	0.0253	0.0020
Rump Length	0.5565	0.5313	0.4578	-0.4757	0.8031
P-value	0.0021	0.0036	0.0143	0.0105	0.0000
Heart Girth	0.8956	0.8298	0.7920	-0.3717	0.6716
P-value	0.0000	0.0000	0.0000	0.0514	0.0001
Barrel Circumference	0.8659	0.6843	0.7332	-0.3264	0.6507
P-value	0.0000	0.0001	0.0000	0.0901	0.0002
Hip Height	0.5469	0.4541	0.5262	-0.2764	0.4197
P-value	0.0026	0.0152	0.0040	0.1546	0.0262
Withers Height	0.4940	0.4635	0.5248	-0.3440	0.4029
P-value	0.0075	0.0130	0.0041	0.0731	0.0335

	Loin Length	Rump Length	Heart Girth	Barrel Circumference	Hip Height	Wither Height
Loin Length	1.0000					
P-value						
Rump Length	0.4292	1.0000				
P-value	0.0226					

	Loin Length	Rump Length	Heart Girth	Barrel Circumference	Hip Height	Wither Height
(Table Cont'd)						
Heart Girth	0.5241	0.6126	1.0000			
P-value	0.0042	0.0005				
Barrel Circumference	0.4903	0.5604	0.8433	1.0000		
P-value	0.0081	0.0019	0.0000			
Hip Height	0.4331	0.5340	0.6393	0.5917	1.0000	
P-value	0.0213	0.0034	0.0003	0.0009		
Wither Height	0.4051	0.5012	0.6446	0.4906	0.9188	1.0000
P-value	0.0325	0.0066	0.0002	0.0080	0.0000	

VITA

Trent Dugas, son of Drew and Aimye Dugas, grew up in the small town of Loreauville, Louisiana. He graduated from Loreauville High School in 2013. He enrolled in Louisiana State University and received his bachelor's degree in Animal Science in 2016. It was here that he developed his knowledge and passion for animal production and meat science. Upon completion of his bachelor's degree, Trent again enrolled at Louisiana State University in the spring of 2017 and will graduate in May of 2019 with an M.S. in Animal Sciences. Trent will pursue employment in the meat industry and continue to gain knowledge about production and processing of meat.